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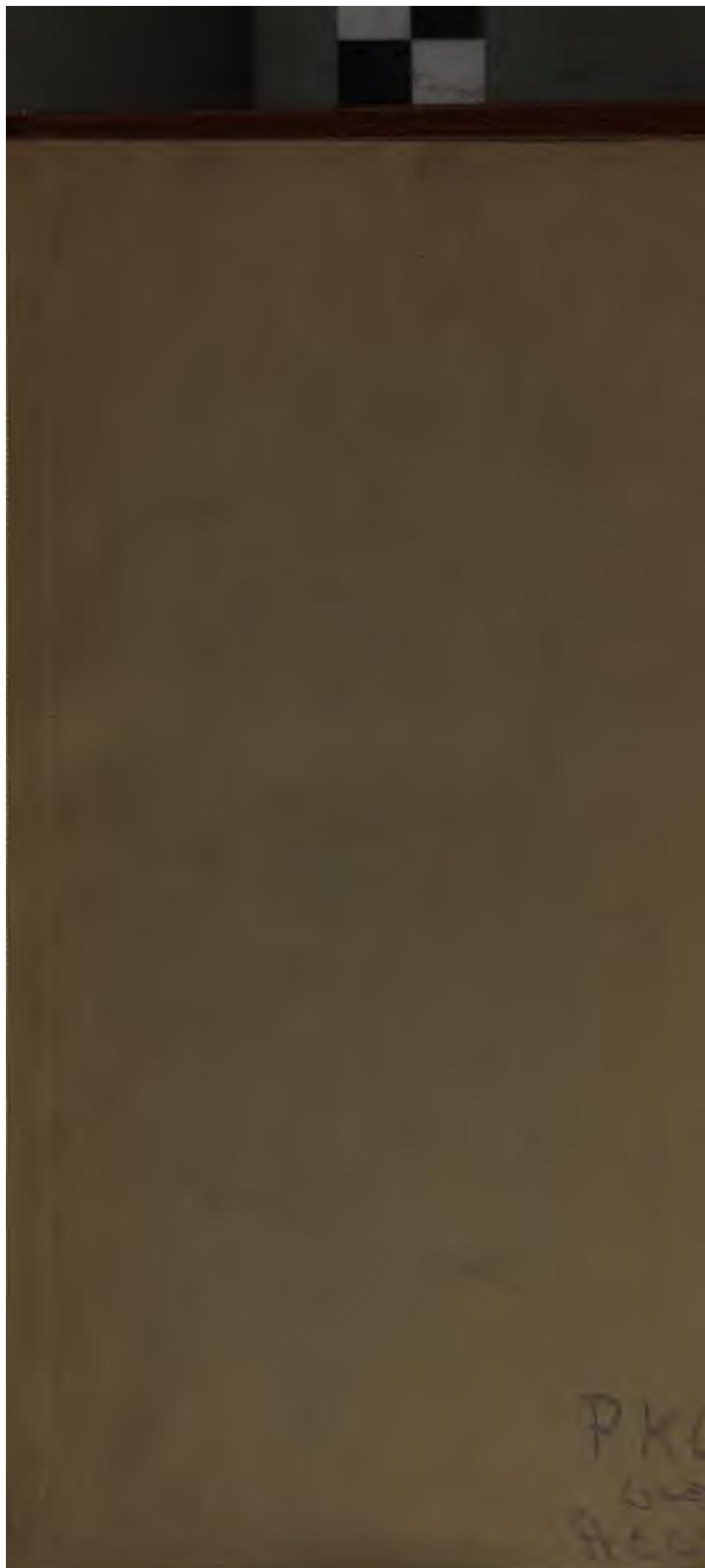
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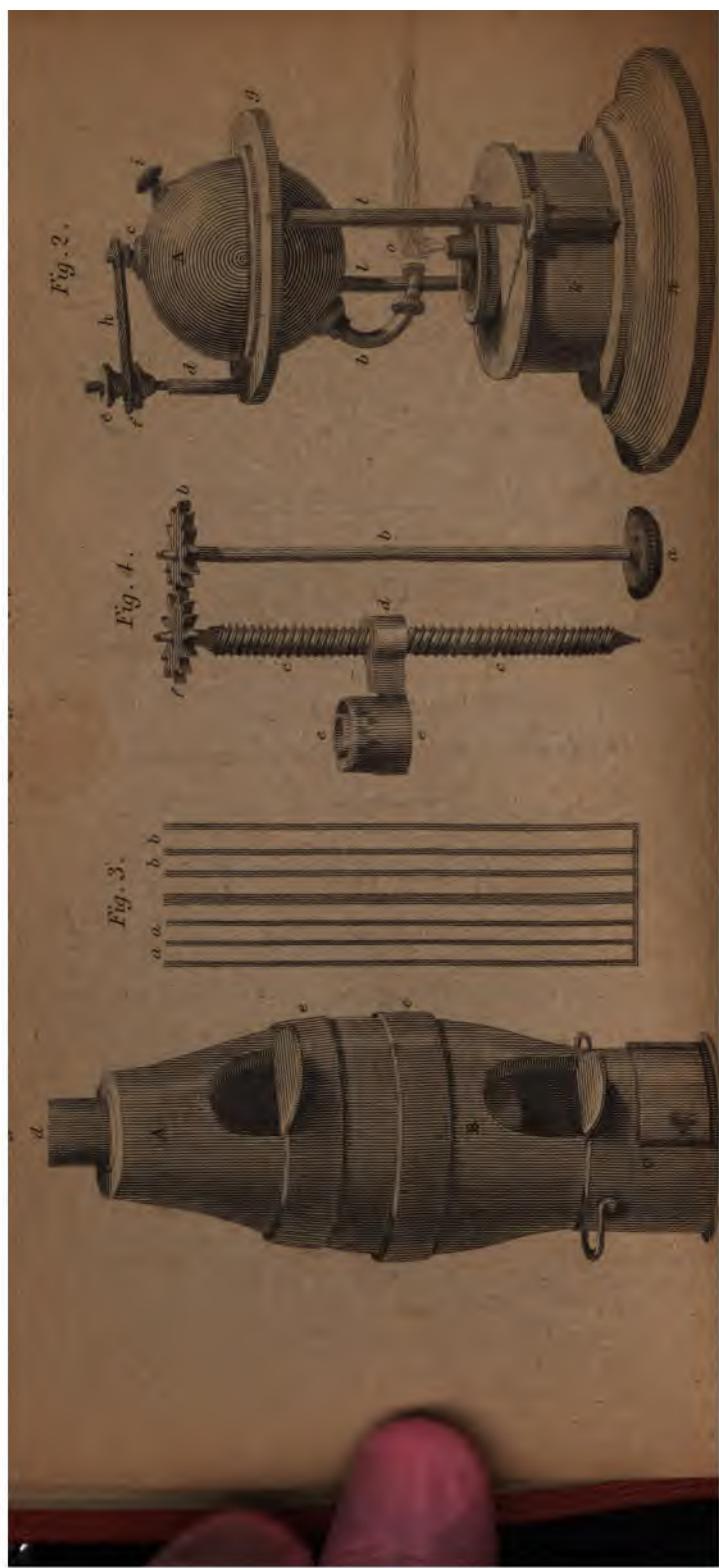




A
SYSTEM
OF
THEORETICAL AND PRACTICAL
CHEMISTRY.







A
SYSTEM
OF
THEORETICAL AND PRACTICAL
CHEMISTRY.

IN TWO VOLUMES, WITH PLATES.

BY
FREDRICK ACCUM,
TEACHER OF PRACTICAL CHEMISTRY, PHARMACY, AND MINERALOGY,
AND
CHEMICAL OPERATOR
IN THE ROYAL INSTITUTION OF GREAT BRITAIN.

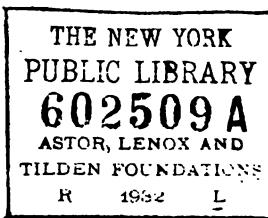
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1803,



From the Friends of G. HAYDEN,
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SPONTANEOUS DECOMPOSITION OF ANIMAL
MATTER.

A LIST OF
CHEMICAL PREPARATIONS,

Prepared and Sold, in as pure a State as possible, by
Messrs. ACCUM and Co. Old Compton Street, Soho.

METALS.—Arsenic, Tungsten, Molybdena, Cobalt, Nickel, Bismuth, Antimony, Mercury, Zinc, Tin, Lead, Iron, Copper, Silver, Gold, Platina.

Collections of Ores, containing the preceding Metals, in their native state, systematically arranged.

ACIDS—Arsenic, Arsenious, Tungstic, Molybdic, Acetous, Acetic, Oxalic, Tartarous, Citric, Malic, Gallic, Succinic, Benzoic, Camphoric, Mucous, Suberic, Prusic, Lactic, Sebacic, Fluoric, Boracic, Muriatic, Oxigenated-Muratic, Phosphoric, Nitric, Nitrous, Sulphuric, &c.

ALCALIES—Barytes, Potash, Soda, Strontia, Lime, Ammonia.

EARTHS—Silex, Alumine, Magnesia, Zircon, Glucine, &c.

RE-AGENTS—Tincture of Cabbage, Litmus, Turmeric, Brazil-wood, and Galls.

Papers tinged with each of these Tinctures.

Tincture of Cabbage, and Tincture of Litmus reddened by Acetous Acid.

Barytic, Strontia, and Lime-water.

Oxalate of Ammonia, Acidulous Oxalate of Potash, and Oxalate of Soda.

Fluete of Soda, and Fluete of Ammonia.

Carbonate of Potash, Carbonate of Soda, and Carbonate of Ammonia.

Acetite and Nitrate of Lead.

Muriate of Gold, Muriate of Tin, and Muriate of Mercury.

Sulphate, Nitrate, and Acetite of Silver.

Green and Red Sulphate of Iron.

Muri-

Muriate, Nitrate, and Acetite of Barytes.
 Triple Prusiate of Potash, Lime, and Ammonia.
 Tann, Alcohol, Sulphuric and Nitric Ether.
 Solution of Soap, Solution of Arsenic, Solution of Gelatine.
 Sulphuret of Potash, Sulphuret of Lime, and Sulphuret of Magnesia.
 Hidro-Sulphuret of Ammonia.
 Glacial Acid of Phosphorus. Phosphate of Soda and Ammonia.
 Black, and White Flux, &c. &c.

ALL THE DIFFERENT GASES—Water impregnated with Sulphurated Hydrogen Gas, with Carbonic Acid Gas, with Carbonated Hydrogen Gas, &c.
PHOSPHORUS—Phosphuret of Lime, Phosphuret of Strontia, and Phosphuret of Barytes. Phosphorated Ether, Phosphorated Alcohol, and Phosphorated Oils.

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PORTABLE STILLS and REFRIGERATORIFS of Tinned Copper. Glass Alembics. Retorts and Receivers.

GRADUATED DETONATING TUBES for firing gases, &c.

Deflagrating Jars—Improved Blow-pipes of Metal and Glass, Eolipile-Blow-pipes.

SPOONS of GOLD, SILVER, and PLATINA.

MORTARS of Iron, Steel, Agate, Flint, Glass, Wedgwood Ware, &c.

CRUCIBLES of Platina, Gold, Silver, Cast Iron, &c.—Muffles, Cupels, and Enamelling Pans—Improved Ingots and Casting Cones, Evaporating Basins—Guitton's Tubes of Safety—Siphons—Jointed Conducting Tubes—Graduated Glass Measures and Cubic Inches—Accurate Balances and Weights in Decimals—Thermometers—Goniometers—Gravimeters—Galvanic Batteries, Piles, Plates, &c.—Wollaston's Apparatus for decomposing Water by Galvanism, or Electricity; and every other Instrument made use of in Experimental Chemistry.



A
SYSTEM
OF
THEORETICAL AND PRACTICAL
CHEMISTRY.

PART XXXIII.

METALS.

AMONG the simple substances which present themselves to our view in examining the products of nature, there are none of which the study is more important than METALS. Their utility is highly interesting. They may be considered as the great instruments of human industry. Many of the mechanic arts could not possibly exist without them, and it is even doubtful whether mankind, would have acquired that degree of civilization which characterizes the present state of society.

ENUMERATION OF METALS.

We are at present acquainted with twenty-two metals, essentially differing from each other, namely,

Arsenic	Antimony
Tungsten	Tellurium
Molybdena	Mercury
Chrome	Zinc
Columbium	Tin
Titanium	Lead
Uranium	Iron
Cobalt	Copper
Nickel	Silver
Manganese	Gold
Bismuth	Platina.

We abandon the ancient division of these substances into noble or perfect, and semi or imperfect metals, but class them into different genera; proceeding in a gradation from those which possess, in a certain sense, the *least*, to those which possess the *most* metallic properties.

CLASSIFICATION OF METALS.

1. *Very brittle and acidifiable metals.*

Arsenic	Molybdena
Tungsten	Chrome
Columbium.	

2. *Less brittle and simply oxidable metals.*

Titanium	Manganese
Uranium	Bismuth
Cobalt	Antimony
Nickel	Tellurium.

3. *Partly ductile and oxidable metals.*

Mercury
Zinc.

4. *Very ductile and easily oxidable metals.*

Tin
Lead
Iron
Copper.

5. *Exceedingly ductile and difficultly oxidable metals.*

Silver
Gold
Platina.

NATURAL HISTORY OF METALS.

the metals are found in the bowels of the earth, though sometimes they are on the surface. They are met with in different combinations with other matters, such as sulphur, oxygen, acids; particularly with the carbonic, muriatic, sulphuric, phosphoric acids. They are also found combined with each other and sometimes, though rarely, in a pure metallic state, distinguishable by the naked eye.

In their different states of combination they are said to be mineralized, and are called ORES. The ores of metals are for the most part, found in nature in mountainous districts; always in such a form a continued chain. There are mountains which consist entirely of iron ore, but in general the metallic part of a mountain bears a very inconsiderable proportion to its bulk. Ores are also met with in the cavities or

Class I....BRITTLE AND ACIDIFIABLE METALS.

ARSENIC.

PART XXXIV.

SECT. I.

NATURAL HISTORY OF ARSENIC.

ARSENIC is scattered in great abundance over the mineral kingdom. It is found in black heavy masses of little brilliancy, called *native arsenic*, (*testaceous arsenic*.) It is found in different parts of Germany. Mineralized by sulphur, it forms *sulphurized arsenic*, or *orpiment*. This mineral is met with in Italy, about Mount Vesuvius. There are two varieties of this ore which differ from each other in colour, occasioned by the different proportions of its component parts. The one is called *yellow sulphurized arsenic*, or *orpiment*; the other, *red sulphurized arsenic*, or *realgar*, (*ruby arsenic*); both are met with in Hungary and different parts of Germany. The colour of the first ore is a lemon yellow, inclining sometimes to a green; the

colour of the latter is a ruby red; it is more transparent than the former, and found in compact solid masses, sometimes crystallized in bright needles. Arsenic united to oxygen constitutes the ore called *native oxid of arsenic*. This ore is scarce; it is generally found of an earthy appearance, or as an efflorescence, coating native, or metallic arsenic; its colour is a whitish grey; it is rarely met with crystallized. Arsenic exists likewise alloyed with cobalt, antimony, tin, copper, lead, and various other metals.

PROPERTIES OF ARSENIC.

Arsenic is a brittle metal, and in the recent fracture of a lively bright colour, between tin-white and lead-grey; but, on exposure to the air, it soon loses its metallic lustre, and turns prismatic, dull, and at last black. Its specific gravity is between 8.310 and 5.763 according to its texture. Its hardness surpasses that of copper; but its ductility is so little and its brittleness so great that it is readily converted into a powder by the hammer. It is entirely volatilized when heated to 350° Fahr. It sublimes in close vessels, and then crystallizes in tetrahedra, or octahedra. When heated with the access of air, it emits a strong smell of garlic, and burns with a bluish white flame. It combines with sulphur by fusion. It unites to phosphorus and combines with most of the metals. It gives a white colour to copper and renders many of the ductile metals brittle. When mixed with hyper-oxygenated muriate of potash, it detonates strongly by the stroke of a hammer. It is soluble in hydrogen gas by heat. It does not decompose water alone. It decomposes sulphuric acid by heat. The nitric and nitrous acids oxidate it rapidly. The muriatic acid attacks it with heat. The oxygenated muriatic acid when in a gaseous state inflames it instantly. It is nearly unalterable by the fluoric, boracic, phosphoric and carbonic acids. It unites with alkaline sulphurets and hydro-sulphurets. It is a deadly poison.

METHOD OF OBTAINING ARSENIC.

METHOD OF OBTAINING ARSENIC.

In order to obtain metallic arsenic, mix two parts of the white oxid of arsenic of commerce, with one of black flux (obtained by detonating one part of nitrate of potash with two of acidulous tartrite of potash) and put the mixture into a crucible or melting pot. Invert over this, another crucible, lute the two together with a little clay and sand, and apply gradually a red heat to the lower one. The oxid of arsenic will be reduced and be found lining the upper crucible in small crystals of a metallic brilliancy.

RATIONAL... The charcoal of the black flux takes the oxygen from the white oxid, and forms carbonic acid gas; which flies off during the process, and the oxid becomes reduced to the metallic state. This reduction of the oxid is greatly facilitated by the alkali of the flux.

REMARK... In order to obtain arsenic in a state of absolute purity, the metal before obtained must be reduced to powder, dissolved by heat in nitro-muriatic acid; and then precipitated by immersing into the solution a plate of zinc. The arsenic is thus precipitated in a fine powder, and may be reduced to its metallic state, by exposing it in a covered crucible to a moderate heat.

If it be kept under water its metallic brilliancy may be preserved. This effect is still better produced by alcohol.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ARSENIC.

EXPERIMENT I.

Arsenic burns and is volatilized by heat.

INTRODUCE into a crucible, made red-hot in a coal-fire, a small quantity of arsenic ; it will soon begin to burn and become volatilized.

If this crucible be covered with another, and the joinings luted with a little clay, the arsenic will be found in the upper one in brilliant crystals.

EXPERIMENT II.

Arsenic stains copper white.

Insert a little arsenic, reduced to fine powder, between two polished plates of copper ; bind them closely together with iron wire and heat them. The inner surfaces of the copper plates will be rendered white by the arsenic.

The union of arsenic with copper may likewise be effected by fusing one part of arsenic and four of copper, in a common crucible. The alloy produced is a white metal.

REMARK...It is necessary in this experiment to cover the substances in the crucible with common salt, to prevent the action of the air.

EXPERIMENT III.

Arsenic decomposes sulphuric acid.

Put into a retort one part of arsenic reduced to a fine powder and three of sulphuric acid, direct the neck of the retort under a receiver filled with mercury, in the mercurial pneumatic trough, and apply the heat of a lamp. When the mixture has boiled some time, sulphureous acid gas will pass into the receiver.

RATIONALE...The arsenic subtracts the oxygen of part of the sulphuric acid, which becomes converted into sulphureous acid gas. The oxid of arsenic which is produced, is dissolved in the other part of the acid.

EXPERIMENT IV.

Arsenic combines readily with sulphur.

If one part of arsenic and four or five of sulphur be hastily fused together in a well closed crucible, the two substances unite and form a yellow compound, called sulphuret of arsenic.

EXPERIMENT V.

Arsenic combines with phosphorus.

Put equal quantities of arsenic, reduced to powder, and phosphorus, into a Florence flask; pour water upon them, so as to cover them an inch, and apply the gentle heat of a lamp. The

arsenic and phosphorus will unite and form a phosphuret of that metal.

This combination may likewise be conveniently effected, by gently heating, in a close phial, equal parts of phosphorus and pulverized arsenic.

EXPERIMENT VI.

Tin and arsenic may be alloyed by fusion.

Put into a crucible placed in a fire, seven parts of tin and one of arsenic, melt the mixture and when completely united pour it out into an ingot. The alloy obtained will be found to be of a white colour, it is much harder, more sonorous, and less fusible than tin.

EXPERIMENT VII.

Arsenic detonates with hyper-oxygenated muriate of potash by percussion.

Put a few grains of arsenic in contact with hyper-oxygenated muriate of potash, on an anvil or any smooth solid surface, and give it a smart blow with a hammer. The mixture will explode with a loud report.

The spontaneous accension of arsenic in oxygenated muriatic acid gas has been exemplified already (page 338).

ANALYSIS OF ORES OF ARSENIC.

Take any quantity of the ore, reduce it to powder, and introduce it into a Florence flask, pour over it three times its own weight of nitro-muriatic acid, composed of one part of nitric,

and one and a half of muriatic acid; assist the action of the acid by the heat of a lamp or candle. When no further action ensues, if the ore is not completely dissolved, add a fresh quantity of acid, and proceed as before till all is dissolved. Then let the solution subside, (for if the arsenical ore contained silver, a white heavy precipitate will be formed during the process,) filtr it, and evaporate it in a Wedgwood's bason to at least one-fourth. When so far concentrated add distilled water to the solution, so long as it occasions any turbidness, which may be known by filtering, from time to time, a small quantity of the mixture, and assaying the filtered fluid by a fresh addition of water. The white precipitate which is thus obtained is the quantity of arsenic which was contained in the ore. In order to reduce it to the metallic state it may be re-dissolved in muriatic acid, and precipitated by immersing into this solution a plate of zinc, mixing with it at the same time a tenth part of a solution of alcohol.

If the ore contained silver the white precipitate mentioned before must be dried, and then mixt with double its weight of carbonate of soda freed from its water of crystallization, and exposed in a crucible to a white heat for at least half an hour. The silver will be found at the bottom of the crucible in a metallic state.

The sulphurated ores of arsenic may be analyzed in a similar manner, by treating them with nitro-muriatic acid. In this case an addition of acid will not dissolve the residue. The arsenic may be separated, by first concentrating the solution, and then adding to it water. The sulphur may then be collected on a filter, and dried between bibulous paper in a heat not above that of boiling water. If it be pure sulphur, it may be volatilized by a continued gentle heat.

MOLYBDENA.

PART XXXVI.

NATURAL HISTORY OF MOLYBDENA.

MOLYBDENA exists mineralized by sulphur in the ore called *sulphuret of Molybdæna*. This ore, which is likewise scarce, is so similar in several of its properties to plumbago that they were long considered as varieties of the same substance. It is of a light lead-grey colour, its surface is smooth, and feels unctuous, its texture is lamellated, it soils the fingers, and marks paper bluish-black, or silver-grey. It may be cut with a knife. It is generally found in compact masses; seldom in particles, or crystallized. It is met with in Sweden, Spain, Saxony, Siberia and Iceland. Scheele showed that a peculiar metallic acid might be obtained from it; and later chemists have succeeded in reducing this acid to the metallic state. We are indebted to Mr. Hatchett, for a full and accurate analysis of this ore.*

VOL. II.

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* See his valuable paper on the analysis of the Corinthian Molybdate of Lead, Phil. Trans. 1796.

PROPERTIES OF TUNGSTEN.

Tungsten appears of a steel grey colour. Its specific gravity is about 17.6. It is one of the hardest metals, but it is exceedingly brittle; and is said to be almost as infusible as platina. Heated in the air it becomes converted into a yellow pulverulent oxid, which becomes blue by a strong heat or when exposed to light. Tungsten combines with phosphorus and sulphur, ~~and~~ with silver, copper, iron, lead, tin, antimony, and bismuth; but it does not unite with gold and platina. It is not attacked by the sulphuric, nitric, or muriatic acids; nitro-muriatic acid acts upon it very slightly. It is oxidable and acidifiable by the nitrates, and super-oxigenated muriates. It colours the vitrified earths or the vitreous fluxes, of a blue or brown colour. It is not known what its action will be on water and different oxids. Its action on the alcalies is likewise unknown. It is not employed yet, but promises real utility, on account of its colouring property, as a basis for pigment, since the compounds it is said to form with vegetable colouring matters afford colours so permanent as not to be acted on by the most concentrated oxigenated muriatic acid, the great enemy of vegetable colours.

METHODS OF OBTAINING TUNGSTEN.

The method of obtaining metallic tungsten is a problem in chemistry. Scheele, Bergman, and Gmelin did not succeed in their attempts to procure it. Klaproth* tried to reduce the yellow oxid of this metal with a variety of combustible substances, but without success. Messrs. Ruprecht and Tondy† say they have obtained this metal by using combustible substances alone; and by a mixture of combustible and alcaline matter.

* Crelle's Annal, 1786, vol. II, p. 502: † Ann. de Chem. tom. VIII, p. 4.

The following process is recommended by Richter, an ingenious German chemist.*

Let equal parts of tungstic acid and dried blood be exposed for some time to a red-heat in a crucible; press the black powder which is formed into another smaller crucible, and expose it again to a violent heat in a forge for at least an hour. Tungsten will then be found, according to this chemist, in its metallic state in the crucible.

REMARK... This author very properly objects to the use of alkalies or alkaline salts in this process as they are apt to form neutral salts with the tungstic acid and in this way prevent its reduction. From the facility however with which Ruprecht and Richter seem to have obtained this metal it may fairly be questioned whether it was intirely free from all admixtures.

The existence of metallic Tungsten being doubtful, we must content ourselves, with examining the properties of this substance in the state of an oxid, for which we refer the reader to the article *Tungstic acid*.

The same must be the case with those metals which possess few metallic properties; or whose scarcity has hitherto prevented chemists from experimenting upon them; when a sufficient quantity of the ores can be procured, their characters and properties will no doubt be investigated. Hitherto chemists have paid attention to them when in combination with oxigen, or when they are brought to the state of an acid; we are consequently unable to say much about their metallic properties in the present state of our knowledge.

We are inclined to believe with Mr. Hatchett† that the time is perhaps not very far distant, when some of the newly discovered metals, which are now considered as simple, primitive, and distinct bodies, will be found to be compounds; but until that happens we are obliged to consider them as substances *sui generis.*

* Richter über die Neuen Gegenstände der Chemie, 1 Stück, p. 49.
† Nicholson's Journal, July, 1802, p. 179.

means, with the potash, and the carbonic acid of the latter unites to the lead, and forms an insoluble compound (carbonate of lead.) In order to ascertain its quantity, put it into a flask, and dissolve it, by heat, in nitric acid. On letting sulphuric acid fall into this solution, sulphate of lead will be formed, which may be decomposed by ignition with soda.

Or, the chromate of lead may be treated with muriatic acid; in that case, muriate of lead precipitates, and the chromic acid remains in solution. This process must be repeated until the whole of the ore is decomposed. The solution then contains chromic acid mixt with a little muriatic acid. From the latter it may be freed by dropping into it a solution of nitrate of silver. Muriate of silver will be formed, which, when collected on a filter and dried, may be reduced to the metallic state, by fusing it with double its weight of soda.

The *chromate of iron* may be analyzed in the following manner: Let one part of the ore mixt with eight times its weight of potash, be fused in a crucible for at least one hour. Pour the mass into a convenient vessel, and when cold, boil it in a sufficient quantity of water, for a quarter of an hour, and filter it. The residue which remains on the filter must be transferred into muriatic acid, and digested for a few minutes. The acid is then to be separated by filtration, and the residue treated as before, alternately with potash, and muriatic acid, until the whole is dissolved. The alkaline solutions must then be added together, and the same must be done with the acid ones. The first solutions contain the chromic acid of the ore, and the latter the iron, together with a little chromic acid. In order to free it from it, a solution of carbonate of potash may be dropped into it, and the precipitate boiled for a few minutes in a solution of potash. What remains is pure oxid of iron. The chromic solution must now be saturated, by gradually adding nitric acid, and then be decomposed, by adding nitrate of lead. The precipitate which ensues is chromate of lead, 100 parts of it indicate 35 of chromic acid.

COLUMBIUM.

PART XXXVIII.

NATURAL HISTORY OF COLUMBIUM.

To the acidifiable metals, which have been sometime known to the chemical world, we have to add one, of a more recent discovery, called Columbium, for which we are indebted to Mr. Hatchett, who discovered it in the year 1802.* This accurate analyst, being engaged in examining and arranging some minerals in the British Museum, observed a specimen of ore which greatly resembled the Siberian chromate of iron. It appeared that the mineral in question was sent from the mines of Massachusetts in North America.

Mr. Hatchett describes this ore as being of a dark brownish grey externally, and more inclining to an iron grey internally; the longitudinal fracture, he found, lamellated; and the cross fracture had a fine grain. Its lustre was vitreous, slightly inclining in some parts to metallic; moderately hard and very brittle. The colour of the streak or powder was dark chocolate brown. The

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* Philosophical Transactions, 1802. Part I. p: 40.

diluted nitric acid. A small quantity of a white insoluble substance, similar to that which was obtained from the alkaline solution, was separated during this process. From this nitric solution Mr. Hatchett obtained by means of ammonia, a precipitate of oxid of iron.

The different alkaline solutions which had been made subsequent to that which has been first mentioned, were mixed together, and being super-saturated with nitric acid, yielded the white insoluble precipitate. The fluid from which this precipitate had been separated by nitric acid, was then saturated with ammonia, and being boiled afforded about two grains of oxid of iron.

100 grains of the ore thus analyzed, yielded to Mr. Hatchett
42 of oxid of iron, and
155 columbic acid, the properties of which will be noticed under that article.

Such were the products obtained in the analysis; but as Mr. Hatchett was confined to experiment upon a small quantity of ore, and could not repeat his researches, without destroying the remaining part of the only specimen at present known; he does not wish the above stated proportions of the component parts of the ore, to be considered as absolutely exact.

Class II....LESS BRITTLE AND SIMPLY OXIDABLE METALS

TITANIUM.

PART XXXIX.

NATURAL HISTORY OF TITANIUM.

THIS is likewise a newly discovered metal. It was noticed by Macgregor as existing in the state of an oxid, mixed with iron, manganese, and silex, in a greyish black sand found in the vale of Menachan in Cornwall, and thence named *Menachanite*, or *oxid of Titanium, combined with iron*. It has also been discovered by Klaproth, in an ore named *Titanite*, or *oxid of Titanium, combined with lime and silex*. This ore is generally met with crystallized in four-sided prisms, not longer than a quarter of an inch. Its colour is a yellowish red, or blackish brown; it is opaque and of an imperfect lustre. It breaks with a foliated, uneven, or conchoidal fracture. It exists also in an ore called *Red schorl of Hungary*, or *red oxid of Titanium*. This ore, which is found generally crystallized in rectangular prisms, is of a brownish red colour; and its texture foliated. In all these ores titanium exists in the state of an oxid.

PROPERTIES OF TITANIUM.

tanum has been only obtained in very small agglutinated is. It is of a red-yellow and crystalline texture, brittle and emely refractory. Its specific gravity is about 4.2; when en with a hammer while yet hot from its recent reduction it s a change of colours of purple, violet, and blue. In very se heat it is volatilized. Most of the acids have a striking n on this metal. Nitric acid has little effect upon it. It is oxidable by the muriatic acid. It is not attacked by the es. Nitro-muriatic acid converts it into a white powder, muriic acid when boiled upon it is partly decomposed. It is of the most infusible metals. It does not combine with m-, but it may be united to phosphorus.* It does not alloy copper, lead, or arsenic, but combines with iron.

METHOD OF OBTAINING TITANIUM.

is extremely difficult to reduce the acid of titanium to the ilic state. However the experiments of Elipsoth, Hecht Vanquelin, have proved its reducibility. According to the latter, one part of oxid of titanium is to be melted with six otash; the mass when cold is to be dissolved in water. A te precipitate will be formed which is carbonate of titanium. s carbonate is then made into a paste with oil, and the mix- is put into a crucible filled with charcoal powder and a little nine. The whole is then exposed for a few hours to the on of a strong heat. The metallic titanium will be found in ackish puffed up substance, possessing a metallic appearance.

* Chenevix's paper in Nicholson's Journal, V, p. 724.

that it may be scraped with a knife. It has but little lustre. Its specific gravity is 6,440. It is more difficult to be fused than even manganese. When intensely heated with phosphate of iron and ammonia, or glacial phosphoric acid, it fuses with them into a grass-green glass. With soda or borax it melts only into a grey, opaque, scoriaceous bead. It is soluble in sulphuric, nitric, and muriatic acids. It combines with sulphur and phosphorus, and alloys with mercury. It has not yet been combined with other combustible bodies. It decomposes the nitric acid and becomes converted into a yellow oxid. The action of uranium alone upon water, &c. is still unknown, probably on account of its extreme scarcity.

METHOD OF OBTAINING URANIUM.

In order to obtain uranium, the *pechblende* is first freed from sulphur by heat, and cleared from the adhering impurities as carefully as possible. It is then digested in nitric acid; the metallic matter that it contains is thus completely dissolved, while part of the sulphur remains undissolved, and part of it is dissipated under the form of sulphurated hydrogen gas. The solution is then precipitated by a carbonated alkali. The precipitate has a lemon-yellow colour when it is pure. This yellow carbonate is made into a paste with oil and exposed to a violent heat, and is bedded in a crucible containing and lined with charcoal.

Klaproth obtained a metallic globule 28 grains in weight, forming a ball of 50 grains of the yellow carbonate with a little wax, and by exposing this ball in a crucible lined with charcoal to a heat equal to 170° of Wedgwood's pyrometer.

Richter obtained in a single experiment 100 grains of metal which seemed to be free from all admixture.

ANALYSIS OF ORES OF URANIUM.

These ores may be treated with nitric acid. In order to analyze *black ore of uranium* or *pechblende*, let one part of the ore reduced to powder be digested in four or five of diluted nitric acid. Repeat this process two or three times. The undissolved residue is a mixture of the silic, sulphur, and iron, which are contained in the ore. To get rid of a small quantity of iron, which generally is taken up by the acid, immerse a polished plate of zinc in the solution. The iron will thus be precipitated. On evaporating the solution a precipitate will ensue which is nitrate of lead. The solution must be filtered, and a solution of potash added to it, to throw down the zinc and uranium. The precipitate obtained by means of this agent must be transferred into a phial containing liquid ammonia, and suffered to stand for some days. The oxid of zinc will thus be dissolved, and the oxid of uranium be left behind. It must therefore be separated on a filter, washed, dissolved in diluted sulphuric acid, and then evaporated dry; it will yield crystals of a lemon-yellow colour.

The yellow oxid of titanium; or *uranitic ochre*, may be treated in a similar manner with nitric acid. The uranium will be dissolved in the acid, and the iron left behind.

Green mica, or *chalcolite*, may be analyzed by first dissolving the ore in nitric acid, and then adding to the solution, liquid ammonia in excess. The oxid of titanium will become precipitated, while the copper which was contained in the ore remains dissolved in the solution.

COBALT.

PART XLI.

SECT. I.

NATURAL HISTORY OF COBALT.

COBALT has never yet been found pure in nature, meet with it almost always either in the state of an oxid; all with other metals in the form of a sulphuret; or combined an acid.

Cobalt in the state of an oxid forms the *black cobalt ore*. ore is found in Germany, either in powder of a black or colour, or in compact masses. In the last form it exhibits fracture, rose-coloured spots. There are several varieties of ore.

Cobalt alloyed with other metals forms the *dull white ore*. In this ore, which occurs either amorphous or crystall cobalt is united to iron and arsenic. The colour of this when fresh broken is white or bluish-grey, sometimes w shade of red. It has a metallic lustre. Its texture is com Cobalt united to sulphur forms the *white cobalt ore*. It is with in masses or crystallized in cubes, dodecahedra, and

METHOD OF OBTAINING COBALT.

The process made use of by chemists for obtaining cobalt is to torrify the cobalt ore in an open fire, in order to separate it from the arsenic or sulphur. The cobalt is then obtained in the state of a black oxid more or less dark. This oxid must be mixed with three parts of black flux, and one of decrepitated muriate of soda; some add also half a part of resin. The whole is put into a crucible of such a capacity that at least one-third of it may remain empty, and placed in a furnace exposed to a gentle heat until the resin ceases to burn; the fire must then be raised gradually, in order to bring the crucible to a white heat, and in that state it must be kept until the matters are completely fused. It is then suffered to cool, and having broken the crucible, the cobalt must be separated from the scoriae, which are of a blue colour.

REMARK...It is impossible to obtain cobalt in this way in a state of considerable purity. It always is contaminated with iron.

In order to get rid of this, the cobalt previously oxidated is to be dissolved in nitric acid. The solution must then be evaporated to dryness and the remainder exposed for some time to a red-heat, whereby the nitrated iron becomes decomposed: or the solution of cobalt in nitric acid may be precipitated by pure potash. The precipitate after being washed is dissolved in nitric acid. This solution must be evaporated to dryness, and re-dissolved in as little distilled water as possible, and then precipitated by liquid ammonia. More ammonia is then to be added in order to re-dissolve the precipitate. This ammoniacal solution must be evaporated to dryness, and then mixt with two parts of black flux into a paste with a sufficient quantity of oil, and exposed to a white heat in a forge for at least two hours. A button will thus be obtained which is pure cobalt.

tion, it has a brown rose-colour, or a bright green. Evaporate the solution in a glass basin till it is reduced one-half; on cooling, it will form crystals in small needles called nitrate of cobalt.

EXPERIMENT III.

Cobalt is soluble in nitro-muriatic acid.

(Muriate of cobalt, or green sympathetic ink.)

Put into a matrass one part of cobalt and four of nitric acid. Digest the mixture on a sand-bath for three or four hours, or until the solution be almost completed; then add muriate of soda equal in quantity to the cobalt employed, and four times as much water as nitric acid; filter the liquor through paper, and nitro-muriate of cobalt, or more properly muriate of cobalt, will be obtained.

If letters be traced on clean paper with this solution, they will be invisible; but by exposing the paper to a gentle heat, they will appear of a beautiful green; this colour will disappear as the paper cools, and may be made to appear and disappear successively.

EXPERIMENT IV.

Cobalt combines with acetic acid when in the state of an oxid.

(Acetite of cobalt, or blue sympathetic ink.)

Though acetic acid does not act on cobalt in its metallic state, its oxid is dissolved by it with moderate facility when assisted by heat. The solution of acetite of cobalt is rose-red; it yields a blue sympathetic ink, and is best prepared in the following manner:

Take one ounce of cobalt reduced to powder, put it into a Florence flask and pour over it two ounces of pure nitric acid. Expose the mixture to a gentle heat, and when the cobalt is dissolved, add, by small quantities, a solution of potash, until no more precipitate ensues. Let this precipitate subside, decant the super-natant fluid, and wash the residuum repeatedly in distilled water until it passes tasteless. Then dissolve it in a sufficient quantity of pure distilled vinegar, by the assistance of a gentle heat, taking care to have a saturated solution, which will be known by part of the precipitate remaining undissolved after the vinegar has been digested on it for some time. This fluid is a solution of pure oxid of cobalt in acetic acid, and forms a beautiful blue sympathetic ink, by the addition of about one-eighth part of muriate of soda. This ink, like that made with the nitro-muriatic acid is not visible without heat, and disappears when the paper grows cold.

REMARK.—The cause of this singular change of the solutions of cobalt has not hitherto been explained in a satisfactory manner. It takes place equally in close vessels, so that it can scarcely be ascribed to the action of the air or of moisture. At present it is supposed, (but without any direct proof) to be owing to the partial de-oxidation of the oxid of cobalt by heat, and its re-absorption of oxygen when cold.

These phenomena arrested particularly the attention of former chemists, and accordingly to their fanciful way they gave them the name of *sympathetic inks*; an appellation appropriated to all liquids, the characters of which are colourless and invisible when written on paper, but become visible and coloured by undergoing certain processes, and likewise to those which form characters upon paper susceptible of changing their colour by artificial methods.

ANALYSIS OF ORES OF COBALT.

Take one part of the ore reduced to powder, pour over it in a Florence flask three ounces of nitro-muriatic acid, and assist its action by heat till nearly the whole of the ore is dissolved. Let the mixture stand undisturbed for a few hours, decant the supernatant fluid and filter it gradually. The insoluble residue consists of sulphur and silex. To the before-obtained solution, carbonate of potash dissolved in water must be added as long as a cloudiness appears. When no farther precipitate is produced, filter the whole, wash the precipitate which remains on the filter repeatedly, by pouring distilled water over it and then dry it. The precipitate thus obtained consists of iron, arsenic and cobalt. In order to separate these metals, let it again be dissolved in diluted nitric acid, and decompose this solution by adding liquid ammonia till no further precipitate ensues; collect the precipitate and dissolve it in acetous acid, and suffer this solution to evaporate slowly. By this process the iron gradually becomes separated in the form of a yellow or red powder. The solution must therefore again be filtered. The filtered solution which contains the arsenic and cobalt is now to be mingled with liquid ammonia, till the odour of the latter is predominant. The arsenic will then become separated, and the cobalt remains in solution. By then evaporating the ammoniacal solution, the cobalt will be obtained in the state of an oxid. In order to reduce it to its metallic state, it may be mixed with two or three parts of black flux and ore of borax, and then exposed to a violent heat in a smith's forge, for at least one hour and a half.

NATURAL HISTORY OF NICKEL.

NICKEL.

PART XLII.

NATURAL HISTORY OF NICKEL.

IT is to Cronstedt that we are indebted for the discovery of this metal; though the substance from which he extracted it was known in the year 1694. Cronstedt proved it to be a peculiar metal in the year 1751. Nickel is found in nature generally in the metallic state, more rarely in that of an oxid. Its ores have a coppery red colour, generally covered more or less with a greenish grey efflorescence. The most abundant ore is that termed *sulphuret of nickel* or *kupfernickel*, which is a compound of nickel, arsenic, sulphuret of iron, and sometimes cobalt and copper. This ore occurs either massive, or disseminated, but never crystallized; it is of a copper colour, sometimes yellowish, white, or grey. It exists also combined with oxygen, and a little carbonic acid, in what is called *native oxid of nickel*, (*nickel ochre*); it then has an earthy appearance, and is very friable: it is found coating *kupfernickel*, and seems

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PROPERTIES OF MANGANESE.

ganese is of a whitish grey colour. It is brittle, hard, irregular, and uneven. It is of a metallic brilliancy, but, however, soon loses it in the air. The specific gravity is 6.650. It is very hard, and extremely brittle. It is the most refractory metal, and most difficult to fuse, being at least 150° of Wulfford's pyrometer. Its oxidation is rapid, that exposure to the air is sufficient to render brown, black, and brittle, in a very short time; it can, however, only be kept under water, oil, or mineral spirit, the most combustible of all the metals. It decomposes by heat very rapidly, as well as the greater part of the acids. It decomposes sulphuric acid. It is soluble in acid. It is fusible with carbon, and colors them brown, or red, according to its state of oxidation. It decomposes tinctured by iron. It does not appear to unite with sulphur, bismuth with phosphorus. It unites with gold, silver, and copper, and renders them brittle. It unites with arsenic in close, but does not enter into union with mercury. It forms differently coloured acids by combining with different acids of oxygen.

METHOD OF OBTAINING MANGANESE.

metal is obtained by mixing the black acid, finely powdered, with pitch; making it into a ball, and putting this into a crucible, with powdered charcoal, $\frac{1}{2}$ of an inch thick, and $\frac{1}{2}$ of an inch deep at the bottom. The crucible is then to be filled with powdered charcoal; a cover is to be put on; and the crucible exposed, for an hour, to the heat that can be raised. Or, digest the black acid of use repeatedly, with the addition of $\frac{1}{2}$ of sugar, in acid; dilute the mixture with three times its bulk of

water, filter it, and decompose it by the addition of ~~water~~ collect the precipitate, form it into a paste with oil, and into a crucible, well lined with charcoal. Expose the ~~it~~ for at least two hours to the strongest heat of a forge.

Manganese may also be obtained in the following ~~way~~

Prepare a saturated solution of sulphate of manganese, ~~heat~~ to a boiling heat, and add to it, gradually, a solution of ~~potash~~ potash, until no further precipitate ensues; then filter the solution, and wash the precipitate in water, and ~~then~~ make it into a paste with oil, and proceed as before.

RATIONALE... The sulphuric acid unites to the potash, forms sulphate of potash, and the tartareous acid joins manganese, and forms a tartrite of manganese, which is ~~not~~ posable by heat.

EXPERIMENT III.

The oxid of manganese is soluble in sulphuric acid.

(Sulphate of manganese.)

Let six parts of concentrated sulphuric acid be poured upon one of pulverized black oxid of manganese, and the mixture heated to redness in a glass retort. A vast quantity of oxygen gas will be disengaged, and the residuum will be a hard white mass, which must be powdered and boiled in water. The fluid, when filtered, affords, on adding a little sugar, a coloured solution, which, by evaporation, yields large, transparent, quadrangular crystals, called *sulphate of manganese*.

REMARK. If the coloured solution of sulphate of manganese be exposed to the rays of the sun, it loses its colour, and reappears when removed into darkness.

RATIONALE. This depends on the de-oxidation of the manganese by vivid light.

EXPERIMENT IV.

Manganese combines with phosphorus.

(Phosphuret of Manganese.)

Manganese may be united to phosphorus by melting equal parts of this metal, and glacial acid of phosphorus, in a crucible with one sixth part of charcoal powder.

Or, by dropping phosphorus upon red-hot manganese.

The phosphuret of manganese obtained in either of these processes is white, brittle, granulated, and of a metallic lustre. It is more fusible than manganese, and unalterable by exposure to the air. When heated, the phosphorus burns, and the manganese becomes oxidated.

PROOFS OF THE PROPERTIES OF MANGANESE.

EXPERIMENT V.

Alcalies unite with the perfect oxid of manganese in a dry way.

These compounds possess the singular property of colour when dissolved in water: for instance, let one black oxid of manganese, reduced to powder, and three parts nitrate of potash, be exposed to ignition in a crucible, the mixture fuses; when the mass assumes a dry earthy appearance, it is partly soluble in water. If a small portion of this powder be put into a glass, containing spring water, the fluid becomes green, then violet, next reddish, and at last totally colourless. This property, which has acquired to the compound, the name of mineral *cameleon*, is destroyed by a very small quantity of sulphuret of potash.

RATIONALE. The nitrate of potash is decomposed, and the black oxid of manganese is brought to the state of a imperfect oxid by the ignition: it then becomes partly soluble in the potash. This solution would appear blue; but as a portion of oxid of iron is always contained in the black oxid of manganese, its colour is changed to green by the yellow tinge of the oxidized iron. This oxid gradually subsides, and the colour disappears. The oxid of manganese now attracts oxygen from the air, and assumes a reddish-brown tinge, which increases more and more, and at last becomes black. It is then precipitated, and the solution becomes limpid.

ANALYSIS OF ORES OF MANGANESE.

Ores of manganese always contain a variety of different earths; it is therefore advantageous to free them from these admixtures by digesting them for some hours, in diluted nitric acid, which has no effect upon the oxide of manganese. This being done, let one part of the ore be digested in six or eight of concentrated muriatic acid, and assist the action by a gentle heat. Repeat the operation, with half this quantity of acid, until no further solution takes place, which may be known by holding a piece of litmus paper over the fumes which arise from the evaporating vessel. If the blue colour of the litmus paper becomes reddened, this operation is at an end, but if its colour becomes discoloured, the operation must be continued. The whole is then to be left undisturbed, (the insoluble part which remains consists mostly of silex,) and afterwards filtered. The muriatic solution may then be decomposed by letting fall into it a solution of carbonate of soda. A copious precipitate will instantly take place, which is of a white colour, but it soon becomes grey, when left exposed to air; or black, when heated in a crucible. This is the oxide of manganese contained in the ore.

BISMUTH.

PART XLIV.

SECT. I.

NATURAL HISTORY OF BISMUTH.

BISMUTH is found in the earth in very few different states, more generally native or in the metallic state. *Native bismuth* is met with in solid masses, and also in small particles dispersed in and frequently deposited on different stones; at Schreeberg in Saxony, Sweden, &c. Sometimes it is crystallized in four-sided tables, or indistinct cubes. It exists combined with oxygen in the *oxid of bismuth*, (*bismuth ochre*) found in small particles, dispersed, of a bluish or yellowish-grey colour, needle-shaped and capillary; sometimes laminated forming small cells. It is also though more seldom united to sulphur and iron in the form of a sulphuret in the *marital sulphurated bismuth ore*. This ore has a yellowish-grey appearance, resembling somewhat the marital pyrites. And, it is sometimes combined with arsenic.

PROPERTIES OF BISMUTH.

Bismuth is of a silver-white colour inclining to red. It so tarnishes and becomes iridescent. It is brittle and can easily be reduced to small particles. It is soft enough to be cut with a knife. It has a lamellated texture. Its specific gravity is 9.80. It requires less heat for fusion than any other metal, tin excepted, melting by a heat = 460° Fahr. It can be volatilized by heat and escapes in the state of greyish-white vapour. It readily unites with mercury and with sulphur. When fused it exhibits on cooling, cubical figures on the surface. It is soluble in sulphuric, nitric, and muriatic acids. The solution in nitric acid is decomposable by mere dilution with pure water. It inflames in oxygenated muriatic acid gas. It is capable of combining with the greatest number of the metals; and when in certain proportion promotes their fusibility remarkably, (page 46). It speedily becomes black by sulphurated hydrogen gas.

METHOD OF OBTAINING BISMUTH.

To obtain bismuth from its ore nothing more is necessary than to fuse the ore with an eighth part of flux in a well closed vessel; the metal will thus be obtained. The metal obtained by this process, however, is far from being in a pure state. It forms the bismuth of commerce.

In order to purify it, let it be powdered, and dissolve it in pure nitric acid and precipitate it, by adding water to the solution. Collect the precipitate on a filter, form it into a paste with oil, and rapidly fuse it with black flux in a closed crucible.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF BISMUTH.

EXPERIMENT I.

Nitric acid dissolves bismuth with great rapidity.

Take nitric acid into a Florence flask or common phial, finally add to it bismuth broken into small pieces till no longer, then filter the solution. This solution, when dried and suffered to crystallize slowly, furnishes a shiningly brilliant salt, which is *nitrate of bismuth*.

Remarkable that if this metallic salt be dissolved again it renders it white and milky, which is a certain mark of this from other metals. The precipitate which is thus called *white sand of bismuth*, and is sold by following the name of *pearl white*.

EXPERIMENT II.

Preparation of nitrate of bismuth.

Take bismuth in fine dust and allow it to stand in cold water. Let the solution stand for a few hours.

comes perfectly transparent, then add a large quantity of distilled water; a precipitate will instantly be formed. When this has subsided decant the super-natant fluid, and wash the white powder repeatedly in distilled water till it passes tasteless, then suffer it to dry spontaneously in the dark, and keep it in a glass bottle.

REMARK...This oxid is used as a cosmetic for whitening the skin, but it is attended with this inconvenience, that it becomes *black* by coming into contact with fetid substances, &c. The eating of boiled eggs is capable of producing this effect. It is thought, and perhaps with reason, that this paint gradually impairs the skin. The liberal use of *any* paint for the skin seems likely to do this, but have we not reason to suspect, from the deleterious effects of this metal on the animal economy, that the liberal use of the oxid of this metal may be attended with effects similar to those which the oxid of lead are known to produce?

EXPERIMENT III.

Combination of bismuth with phosphorus.

Fuse a little bismuth in a crucible, and let fall upon it gradually small pieces of phosphorus. On removing the crucible from the fire, the phosphuret of bismuth will be found adhering strongly to the crucible.

Sulphuret of bismuth may easily be obtained by melting sulphur and bismuth together.

The union of bismuth with metals is not attended with any difficulty.

EXPERIMENT IV.

Oxid of bismuth decomposes muriate of ammonia by heat.

Mix together one part of oxid of bismuth and two of muriate of ammonia, put the mixture into a glass retort, furnished with

a receiver containing a little water, and proceed to distillation: ammonia will pass over and be absorbed by the water in the receiver, and a little oxid of bismuth, mixed with undecomposed muriate of ammonia, will rise and attach itself to the neck of the retort. The remainder, in the retort, is a combination of the metallic oxide with muriatic acid, called *muriate of bismuth*.

ANALYSIS OF ORES OF BISMUTH.

Ores of bismuth and bismuth ochre are very easily examined. The ore called native bismuth may be analyzed by treating it repeatedly with nitric acid assisted by heat. On adding water to the clear solution the bismuth becomes precipitated in the form of a white powder. If the whole should not be precipitated at first, the solution should be concentrated by evaporation, then a second affusion of water will precipitate the remainder. This precipitate formed into a paste with a few drops of oil, and rapidly fused with black flux, gives a button of bismuth.

The rest of the ores of bismuth may be analyzed in a similar manner. The sulphur which they contain will not be acted upon by the nitric acid, it will therefore be left behind and may be separated by filtration.

ANTIMONY.

PART XLV.

SECT. I.

NATURAL HISTORY OF ANTIMONY.

—

ANTIMONY is found *native*, but very rarely; it has, in that state, a metallic lustre, and is found in masses of different shapes; its colour is white, between those of tin and silver. It generally contains a small portion of arsenic. It is likewise met with in the state of an oxid, *antimonial ochre*. The most abundant ore of it is that in which it is combined with sulphur, *the grey ore of antimony, or sulphurct of antimony*. The colour of this ore is bluish, or steel-grey, of a metallic lustre, and often extremely beautifully variegated. Its texture is either compact, foliated, or striated. The striated is found both crystallized, massive, and disseminated; there are many varieties of this ore.

PROPERTIES OF ANTIMONY.

Antimony is of a greyish white, having a slight bluish shade, and very brilliant. Its texture is lamellated, and exhibits plates crossing each other in every direction. Its surface is covered with herbarizations and foliage. Its specific gravity is 6.702. It is sufficiently hard to scratch all the soft metals. It is very brittle, easily broken, and pulverizable. It fuses at 810° Fahr. It can be volatilized, and burns by a strong heat. When perfectly fused, and suffered to cool gradually, it crystallizes in octahedra. It unites with sulphur and phosphorus. It decomposes water strongly. It is soluble in alkaline sulphurets. Sulphuric acid, boiled upon antimony, is feebly decomposed. Nitric acid dissolves it in the cold. Muriatic acid scarcely acts upon it. The oxygenated muriatic acid gas inflames it, and the liquid acid dissolves it with facility. Arsenic acid dissolves it by heat with difficulty. It unites, by fusion, with gold, and renders it pale and brittle. Platina, silver, lead, bismuth, nickel, copper, arsenic, iron, cobalt, tin, and zinc, unite with antimony by fusion, and form with it compounds, more or less brittle. Mercury does not alloy with it easily. We are little acquainted with the action of alkalies upon it. Nitrate of potash is decomposed by it. It fulminates by percussion with oxygenated muriate of potash.

METHODS OF OBTAINING ANTIMONY.

1. To obtain antimony, heat 32 parts of filings of iron to redness, and project on them, by degrees, 100 parts of antimony; when the whole is in fusion, throw on it, by degrees, 20 parts of nitrate of potash, and after a few minutes quiet fusion, pour it into an iron melting cone, previously heated and greased.
2. It may also be obtained by melting eight parts of the ore mixed with six of nitrate of potash, and three of acidulous tartrite of potash, gradually projected into a red-hot crucible, and fused,

putting another in its place; these will be filled with a silvery looking substance, which must be detached with force. This is *white oxid of antimony*.

If this or the former oxid be exposed to a more violent heat, it fuses into a transparent vitreous mass, which varies in colour from a faint yellow to a dark red hyacinth, or orange. This is called *vitreous oxid of antimony, or glass of antimony*.

To ascertain if the fusion be perfect, immerse an iron wire into it, and, when taken out, examine the substance which adheres to it: if it be transparent, and can be easily drawn into a fine thread like common glass, the fusion is complete. Remove the crucible from the fire and pour out its contents upon a heated plate of copper.

All these products are imperfect oxid of antimony.

When nitrate of potash is decomposed by antimony the result is a combination, known under the name of diaphoretic antimony, which is a more perfect oxid than the former.

EXPERIMENT II.

Preparation of perfect oxid of antimony.

Let equal parts of nitrate of potash, and sulphuret of antimony be intimately blended together, project the mixture, by small quantities, into a crucible brought to a red-heat; on the addition of the mixture a detonation will take place. When the whole has been thrown into the crucible, expose it to a heat sufficient to bring the matter into a state of fusion: then remove the crucible from the fire, and having suffered it to cool, separate the scoriae from the oxid of antimony, which will be found in the form of a brown opaque mass.

REMARKS. Native, or crude antimony, as it is called, which is obtained by the smelting of different antimonial ores, has the same nature and properties as the factitious sulphuret of antimony.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ANTIMONY.

EXPERIMENT I.

Antimony combines with different portions of oxygen.

HEN antimony is beaten to powder, and exposed for me to a dull red heat, in an open vessel, it absorbs oxygen, converted into a grey powder. This is called *grey oxid of antimony*.

In the metal is exposed to a higher temperature the product is *black oxid of antimony*. For instance, a triangular crucible in a furnace, not vertically, but in inner of a muffle, with its bottom somewhat inclined. Its must project a little without the door, through which it is faced into the furnace, and it may be luted in that position. Put some metallic antimony into it, and place over its another crucible, to receive the oxid. Bring the metal to heat, and remove the upper crucible every half hour,

followed by another which becomes fixed into a white mass in the receiver; this is what is called *oxigenated muriate of antimony*, formerly termed, from its consistence, *butter of antimony*. As this substance often chocks up the neck of the retort, a burning coal must be applied, to melt it, and make it pass into the receiver. The distillation is to be continued till nothing more passes over, after which the vessels are suffered to cool, and the receiver, being unluted, is exposed to a gentle heat, above a chafing dish to liquefy the oxigenated muriate of antimony.

The properties of this compound are the following: It is exceedingly caustic and instantly destroys the organs of the body. It burns vegetable matters. It fuses by a low degree of heat, and becomes fixed on cooling. It readily loses its whiteness. It is alterable by light. It strongly attracts the moisture of the atmosphere, and resolves itself into a thick, and as it were, oleaginous fluid. It crystallizes in very large parallelopipeds. It is very difficult to keep it in a solid state. It has the property also of being partly soluble, in water, and of being decomposed, in a great measure, by that fluid.

When it is thrown into distilled water, a white oxid of antimony is very abundantly precipitated. This powder, when washed several times in a large quantity of boiling water, and then dried, was formerly called *Algaroth's powder*.

RATIONALE...In this operation, the antimony robs the oxigenated muriate of mercury of part of its oxygen, and becomes oxidated; it then unites to most of the acid, with which it forms oxigenated muriate of antimony. If the distillation be continued after the oxigenated muriate of antimony has passed, fluid mercury will be obtained. Oxygen is therefore more strongly attracted by antimony than by mercury.

If sulphuret of antimony be exposed to distillation with oxigenated muriate of mercury; oxigenated muriate of antimony and red sulphuret of mercury (*cinnabar*) will be obtained. Upon this is founded the following process:

This oxid is however in general, more expeditiously obtained by boiling two parts of sulphuret of antimony, and three parts of sulphur both reduced to fine powder, with a sufficient quantity of water in an iron pot, filtering the liquor and precipitating it with diluted sulphuric acid. The product obtained contains about 75 parts of sulphur in 100.

RATIONAL... All these processes consist in uniting, in a more or less direct manner, the oxid of antimony with sulphurated hydrogen. It is, as Fourcroy has observed, the uniform effect which is produced by all the alkalies, whether they are employed hot or cold, with sulphuret of antimony; they first oxidate the metal, and form with the sulphur a sulphuret charged with hydrogen; this unites with the oxid of the metal which remains in solution. The alkaline sulphuret precipitated afterwards by an acid, in the form of an orange-coloured powder, is in reality nothing but an oxid of antimony, surcharged with sulphurated hydrogen and sulphur.

The principal difference between this preparation and the former consists in this, that the first contains sulphurated oxid of antimony in addition to the hydro-sulphuret of antimony of the latter. In a word, there is no reason to doubt that it is to the sulphurated hydrogen in the mineral kermes, that this medicine is indebted for the virtues by which it is characterized.

EXPERIMENT VII.

Antimony decomposes oxygenated muriate of mercury.

Mix intimately one part of antimony with two of oxygenated muriate of mercury, and introduce the mixture into a glass retort with a wide aperture, leaving about one-third of it empty. Place the retort on a sand-bath, in a reverberating furnace; adjust to the retort a receiver whose capacity is two-thirds less than that of the retort, and proceed to distillation with a gentle heat. During the first half hour there passes over a clear white liquor.

Mercury, united either to muriatic, or sulphuric acid, forms an ore called *horn quicksilver*, or *corneous mercury*. These are, in general, semi-transparent, of a grey or white color, sometimes crystallized, but more frequently in grains. United to oxygen it constitutes the ore called *native acid of mercury*. Mercurial ores particularly abound in Spain, Hungary, China, and South America.

PROPERTIES OF MERCURY.

Mercury, or quicksilver, is the only one of the metals that remains fluid at the ordinary temperature of the atmosphere, but when its temperature is reduced to -40° Fahr. it assumes a solid form. This is a degree of cold, however, that only occurs at high northern latitudes, and, in our climate, mercury cannot be exhibited in a solid state, but by means of artificial cold. When rendered solid it possesses both ductility and malleability. It crystallizes in octahedra, and contracts strongly during congelation. It is divisible into very small globules. It presents a convex appearance in vessels to which it has little attraction, (page 29), but is concave in those to which it does adhere. It becomes electric and phosphorescent by rubbing upon glass, and by agitation in a vacuum. It is a very good conductor of caloric, of electricity, and of galvanism. The specific gravity of mercury is 13.563. Although fluid, its opacity is equal to that of any other metal, and its surface, when clean, has considerable lustre. Its colour is white, similar to silver. Exposed to the temperature of 600° Fahr. it is volatilized. When agitated in the air, especially in contact with viscous fluids, it becomes converted into a black oxid. At a temperature nearly the same as that at which it boils, it absorbs about 14 or 16 per cent. of oxygen, and then becomes changed into a red crystallizable oxid, which is spontaneously reducible by caloric and light at a higher temperature. The greater number of the acids act upon mercury, or are at least capable of combining with its oxid. It combines with sulphur

— trituration, but more intimately by heat. It is acted on by
— alkaline sulphurets. It combines with many of the metals;
— these compounds are brittle, or soft, when the mercury is in
— large proportion. There is a slight union between mercury and
— phosphorus. It does not unite with carbon or the earths.

METHOD OF OBTAINING MERCURY.

Mercury may be obtained pure by decomposing cinnabar, by
means of iron filings. For that purpose take two parts of red
sulphuret of mercury (cinnabar) reduce it to powder, and mix
it with one of iron filings, put the mixture into a stone retort,
direct the neck of it into a bottle, or receiver, filled with water,
and apply heat. The mercury will then be obtained in a state
of purity.

RATIONALE... Sulphuret of mercury consists of sulphur and
mercury; if this be heated in contact with iron, the sulphur quits
the mercury and unites to the iron, and the mercury becomes
disengaged; the residue in the retort is a sulphuret of iron.*

EXPERIMENT XI.

Preparation of red nitrated oxid of mercury.

For this purpose let the nitrate of mercury obtained in this experiment be pulverized in a glass mortar, and put into two more matrasses placed on a sand-bath; the vessels are then to be gradually heated until the contents become of a yellow colour at the surface; suffer them to cool, and the matter they contain will be found in strata of different colours. The lower part of a bright red colour, and the upper of an orange yellow. The mass, when pulverized, is *red oxid of mercury*.

EXPERIMENT XII.

Mercury readily unites to gold, silver, copper, &c.

This may be evinced by rubbing a little mercury on a gold, silver, or copper coin. Or, the combination may be facilitated by igniting the coin, and in that state conveying it into hot mercury. The mercury may be again expelled by heat.

EXPERIMENT XIII.

Mercury is not oxidated at ordinary temperatures; but when temperature is raised nearly to that at which it boils, it combines with oxygen.

Put into a flat bottomed matrass with a long narrow neck, as much mercury as is sufficient to cover the bottom of it to the height of a line or two; fuse the neck of the vessel by means of a blow-pipe, draw it out to a fine point, and form it into a capillary tube: instead of breaking the point to afford access to the external air, it is better to pierce the bulb of the matrass in the centre, and adjust to the hole a bent tube immersed in atmospheric air, in such a manner that the air may be renew-

much easier, and enter in greater quantity, which facilitates the operation. Place the apparatus in a sand-bath, expose it to heat till the mercury boils, and maintain the fire at the same degree for several days. The oxid formed at the surface of the mercury is separated by means of a piece of linen cloth which is pressed. The mercury passes through it, while the oxid remains behind; and this operation must be continued till the mercury is completely oxidated.

This substance has been called *mercury precipitated per se*, or red precipitate of mercury without addition: it is a real oxid of mercury or a combination of this metal with oxygen, which it gradually takes from the atmosphere. It contains about 7 per cent. of oxygen.

EXPERIMENT XIV.

Preparation of fulminating mercury.

It has lately been discovered by Mr. Howard, that mercury, and most, if not all of its oxid, may, by treatment with nitric acid and alcohol, be converted into a whitish crystallized powder, possessing all the inflammable properties of gun-powder, as well as many peculiar to itself. It is obtained in the following manner.

One hundred grains (or a greater proportional quantity, not exceeding 500) are to be dissolved, with heat, in a measured ounce and a half of nitric acid. This solution being poured *cold* upon two measured ounces of alcohol, previously introduced into any convenient glass vessel, a moderate heat is to be applied till effervescence is excited. A white fume then begins to undulate on the surface of the liquor, and the powder will be gradually precipitated on the cessation of action and re-action. The precipitate is to be immediately collected on a filter, well washed with distilled water, and cautiously dried in a heat not exceeding that of a water-bath. The immediate washing of the powder is material, because it is liable to the re-action of the nitric acid;

and while any of the acid adheres to it, it is very subject to the action of light. From 100 grains of mercury about 120 or 130 of the powder are obtained.*

This powder, when struck on an anvil with a hammer, explodes with a stunning disagreeable report; and with such force as to indent both the hammer and the anvil. Three or four grains are as much as ought to be used for such experiments.

The shock of an electric battery sent through it produces a very similar effect.

A quantity of it sufficient to discharge a bullet from a gun, with a greater force than an ordinary charge of gunpowder, always bursts the piece.

From a series of well conducted experiments Mr. Howell concludes that this preparation consists of oxid of mercury, nitric acid, and nitrous etherized gas. Its detonation is owing to the sudden combination of the oxygen with the carbon and hydrogen of these substances, forming aqueous vapour and carbonic acid, and disengaging nitrogen gas; while at the same time so much caloric is suddenly liberated that the elasticity of the gases is not only increased, but the mercury is instantaneously converted into vapour.

EXPERIMENT XV.

Congelation of mercury.

The freezing of mercury was, until lately, a difficult experiment. We are indebted to Mr. Pepys for an easy method of effecting this. This gentleman, with the assistance of some friends, froze, in the winter of 1799, 56lb. of mercury into a solid and malleable mass. The process was as follows.

* Philosoph. Trans. 1800, p. 214.

the mercury was put into a strong bladder, and well secured at the mouth.

The temperature of the laboratory at the time being $+ 33^{\circ}$. A mixture, consisting of muriate of lime, 2lb. at $+ 33^{\circ}$, and the weight of snow at $+ 32^{\circ}$, gave a degree of cold $- 42^{\circ}$. The mercury was put as gently as possible into this mixture, (to prevent a rupture of the bladder), by means of a cloth held at four corners. When the cold mixture had robbed the mercury of so much of its heat, as to have its own temperature thereby raised from $- 42^{\circ}$. to $+ 5^{\circ}$, another mixture, in every respect the same as the last was made, which gave, on trial with spirit-thermometer $- 43^{\circ}$. The mercury was now received into the cloth, and put gently into this new mixture, where it left to be cooled still lower than before.

In the mean time five pounds of muriate of lime, in a large vessel made of tinned iron, and japanned inside and outside, was placed in a cooling mixture in an earthen-ware pan. The mixture in the pan, which consisted of 4lb. of muriate of lime, and the quantity of snow of the same temperature as the former, in one hour reduced the 5lb. of muriate in the pail to $- 15^{\circ}$. The mixture was then emptied out of the earthen pan, and four corks, at proper distances, placed on its bottom to serve as stops for the japanned pail, which was now put into the pan. The corks answered the purpose of insulating the inner vessel, and the external one kept off the surrounding atmosphere, and preserved the air between the two at a low temperature.

To the 5lb. of muriate of lime which had been cooled as already noticed, to $- 15^{\circ}$, and which still remained in the inner vessel, was now added snow, uncompressed and free from moisture, at the temperature of 32° . In less than three minutes we a temperature of $- 62^{\circ}$, a degree of cold which was never produced before in this country, being 94° below the freezing point of water.

The mercury which, by the immersion in the second cooling mixture to which it was exposed, was by this time, reduced to

and white ray of the acid sulphuric acid, a
reaction of light. From 200 grains of mercury
of the powder are obtained.*

This powder, when struck on an anvil
blows with a stunning disengaging report, re-
sulting in instant death. The hammer and the an-
vil grains are as much as ought to be used for such
The shock of an electric battery has a
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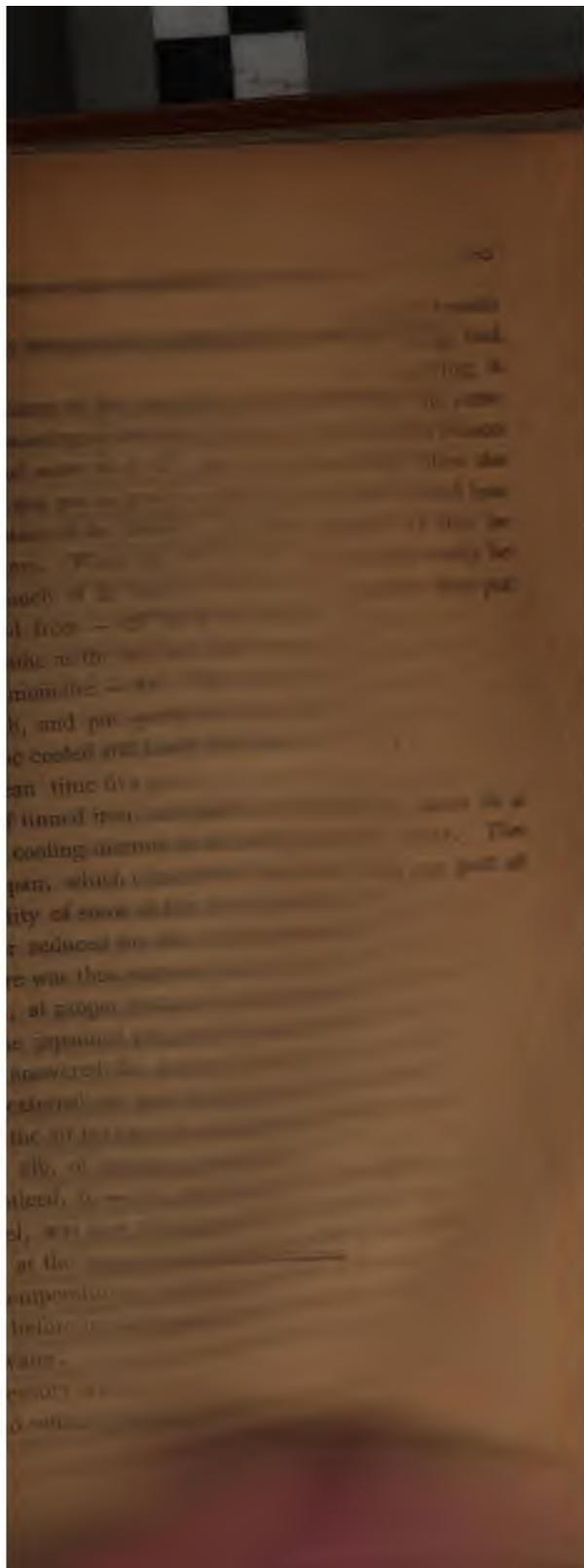
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* *Philosoph. Trans.* 1800, p. 214.



ZINC.

PART XLVIII.

SECT. I.

NATURAL HISTORY OF ZINC.

ZINC is found in nature combined with oxygen, carbonic acid and sulphuric acid; and mineralized by sulphur. Native oxide zinc is commonly called *calamine*. It occurs in a loose, and a compact form, amorphous, of a white, grey, yellow, or brown colour, without lustre or transparency. Combined with carbonic acid, it is called *vitreous zinc ore*, or *native carbonate of zinc*. It is found in solid masses, sometimes in six-sided compressed prisms, both ends being covered with pentagons. Its colour generally greyish inclining to black. It is often transparent. *Sulphate of zinc* is found efflorescent in the form of stalactites; or in rhombs. *Sulphuret of zinc*, or *blende*, is the most abundant ore. It is found of various colours; brown, yellow, hyacinth, black, &c., and with various degrees of lustre and

spärency. This zinc ore is contaminated with iron, lead, laccous and siliceous earths, &c. It occurs both in amorphous masses and crystallized in a diversity of polygonal figures.

PROPERTIES OF ZINC.

Zinc on its fracture appears of a shining white colour, with a slight tint. It possesses some degree of ductility and may be beaten when carefully passed between metallic cylinders in a stamping mill. Its specific gravity is 7.190. It melts at 700°. By a farther increase of heat it is volatilized without melting. When melted in contact with the air, its surface becomes covered with an imperfect oxid; when heated a little above the point of ignition it burns with a bright yellowish white flame, slightly tinged with green, and a white oxid is formed in light smoke, which are carried off by the rapid current of air in the stamping metal. It undergoes very little alteration from the air, its surface becomes slightly tarnished. It is not acted on by water at the usual temperature of our atmosphere; but at that of 100°, it decomposes this fluid rapidly. It is oxidated and dissolved by the greater number of the acids. It has a very strong attraction for oxygen, and therefore precipitates the greater number of the metals from their acid solutions. All the alkalies when heated or boiled with zinc blacken its surface and dissolve a small portion of it. It decomposes muriate of ammonia, sulphate of potash, and various other neutral salts. A mixture of zinc and potash and zinc detonates with rapidity. Sulphur and zinc cannot be united by fusion. Gold, silver, platina, and zinc form brittle compounds with zinc. It easily unites with mercury and tin. It does not combine with lead or bismuth. The most frequent and at the same time most useful combination of zinc is that with copper. It unites with great difficulty to arsenic, iron, and cobalt. It inflames in oxygenated muriatic acid gas, and fulminates by pressure or a blow with oxygenated muriate of potash. It is a very strong conductor of galvanism.

for some hours. The zinc in its metallic form is then in the neck of the retort. In order to obtain the metal in a state dissolve it in diluted sulphuric acid, and boil the treated solution for a few minutes upon granulated zinc filter it, and precipitate it by soda. Collect the precipitate, and when dry mix it with half its weight of charcoal and submit it to a red heat in an earthen retort. Pure zinc will then be found in the neck of the retort.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ZINC.

EXPERIMENT I.

Zinc when exposed to a strong heat burns with a bright flame, and is volatilized.

PLACE a large crucible on two bricks, in a good furnace; incline it, at an angle of 45° , and form before its aperture, a rest to support the cover, in order that the crucible may be shut when necessary.

Put zinc into the crucible, and fuse it by keeping the crucible shut. When of a red heat, uncover it, and a very bright white flame will rise from the surface of the zinc; flakes of exceedingly white and light matter, like cotton, will rise at the same time; this is *white oxid of zinc*. Remove the oxid with a long-handled iron spoon, and more oxid will be immediately formed, which must be removed in like manner. This operation is to be continued till the whole of the zinc is converted into an oxid.

and upon the whole lay another equal
es of copper, and lastly, cover this latter
ader. Lute a cover upon the crockle,
ng one or two hours. The volatilized
ith the copper and convert it into brass.
of the metal after the operation, with
employed; the quantity of zinc united
down.

not been converted into brass, or more
el powder may be again added in the
aining ore, and the operation repeated
ore intense, in order that any zinc re-
be thus extracted. A curious circum-
greater heat is required to obtain zinc
e interposition of copper, than in the
making brass; in which the separation
certainly facilitated by the interposition

Class IV....VERY DUCTILE AND EASILY OXIDABLE METAL

TIN.

PART XLIX.

SECT. I.

NATURAL HISTORY OF TIN.

IT has been much doubted whether tin is ever found native. In the opinion of Kirwan there are sufficient authorities to determine the question in the affirmative. The *native oxid of tin, tin stone*, occurs both massive and crystallized. Its colour is dark brown, sometimes yellowish grey. When crystallized it is somewhat transparent. The *wood tin ore* is a variety of native oxid, termed so from its fibrous texture. This variety has hitherto been found only in Cornwall. It occurs in fragm. which are generally round, and its colour is brown, sometimes inclining to yellow. Tin is also found mineralized by sulphur, associated always with a portion of copper, and often of iron.

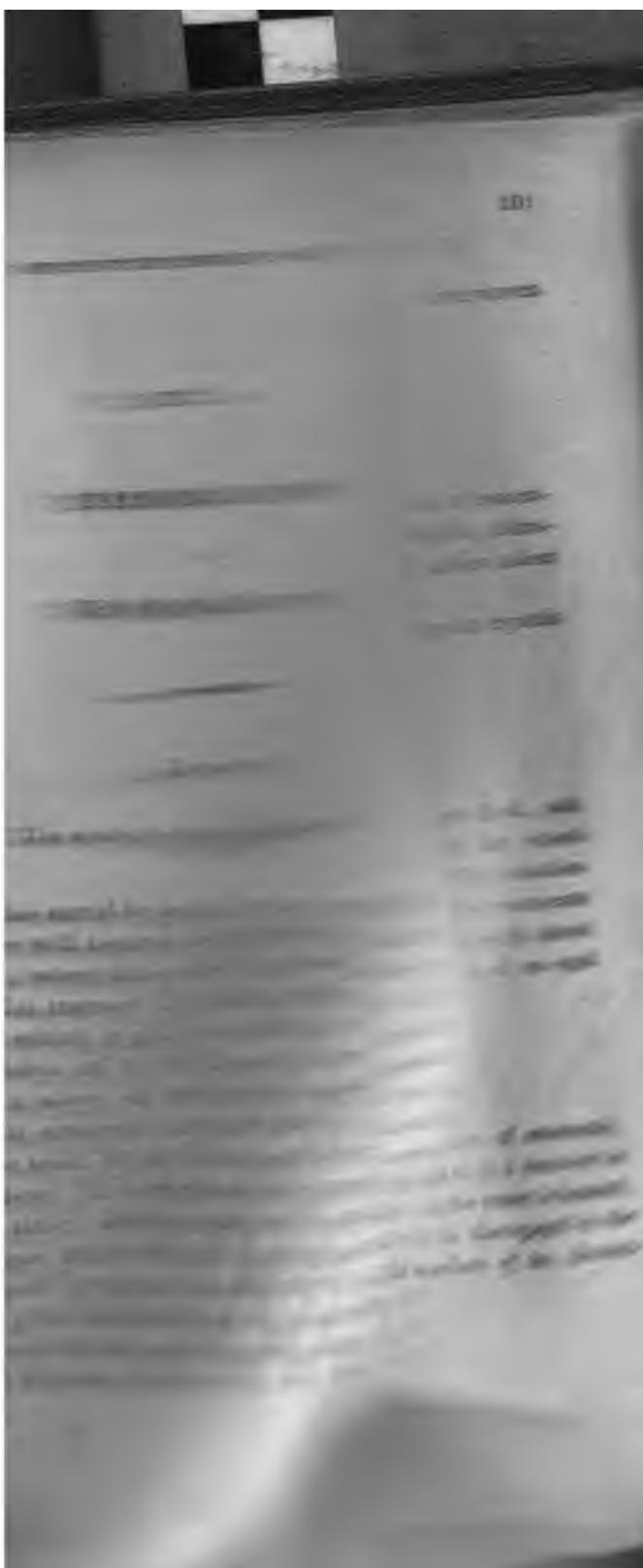
ore is called *tin pyrites*. Its colour is yellowish grey. It has metallic lustre, and a fibrous, or lamellated texture; sometimes exhibits prismatic colours. Tin is comparatively a rare metal, is not found in great quantity any where but in Cornwall, Devonshire; though it is likewise met with in the mines of Sardinia, Saxony, the island of Banca, the peninsula of Malacca, in the East Indies.

PROPERTIES OF TIN.

Tin is of a brilliant white colour, though not quite so white as silver. It is one of the lightest of the metals; its specific gravity, when hammered, being 7.299. It is very fusible, melting at about 410° Fahr. By intense heat it is volatilized. It becomes oxidized by a moderate degree of heat. It easily melts and emits a noise, called the crackling of tin. It is exceedingly soft and ductile. It may be reduced to very thin plates. *Tin foil*, or tin leaf, which is tin beat out, is about $\frac{1}{10}$ part of an inch thick. It has scarcely any sound. It resists the action of the air. It crystallizes in rhombs formed of 11 octahedra. It unites, by fusion, with phosphorus and sulfur. It does not decompose water alone, or in the cold; but it is decomposed by means of many other bodies. It decomposes the sulfuric acid, and unites with the sulphureous acid. It decomposes the nitric acid, and is very soluble in muriatic acid. Nitro-muriatic acid acts on it very readily. It is slightly soluble in hydrofluoric and boracic acids. Phosphoric acid attacks it by heat. Tartaric acid has no perceptible action on it. The oxalic and citric acids dissolve it in small quantities. The alkalies appear to have some action on it by heat. It combines with sulphuret of potash by fusion. It unites with the greater number of the metals with facility. It decomposes muriate of mercury, and muriate of ammonia. It causes nitrate of potash to detonate. It takes fire spontaneously in oxygenated muriatic acid gas, and is capable of combining with two different proportions of oxygen.

METHOD OF OBTAINING TIN.

In order to obtain tin from its ore, a mere fusion of it, with pounded charcoal, is sufficient. Or, a certain quantity of ore is first freed from sulphur and arsenic by torrefaction; which it is mixed with equal parts of potash, one half of common resin, and two parts of black flux; the mixture is then fused in a crucible covered with charcoal, by means of which the metal is recovered in its metallic state. In order to obtain pure tin let the tin obtained before be rapidly dissolved in strong muriatic acid with heat. Thus some of the metals it may contain will be held in solution, and others become oxidated, but muriatic, or nitro-muriatic acid will, on digestion, take up these oxidized metals, after sufficient ablation, leave that of tin, which may afterwards be reduced by mixing it when pulverized with double its weight of a flux formed of equal parts of pitch and borax, or resin and borax, and putting it into a covered crucible, lined with charcoal, which must be placed in a forge, and strongly heated for a quarter of an hour.



EXPERIMENT IV.

Tin combines very readily with sulphur.

This sulphuret may be obtained by fusing together in a cover crucible, one part of tin with four or five of sulphur. The compound is heavier than tin, and not so fusible.

EXPERIMENT V.

Tin combines also with phosphorus.

Take equal parts of tin filings and glacial acid of phosphorus and one eighth part of charcoal-powder: mix these three substances intimately, and fuse them in a crucible; a few grains of a metallic appearance, and of a pretty large size will be obtained. These do not differ in appearance from tin, but when melted in the blow-pipe, the phosphorus abandons the metal and burns on its surface.

REMARK...In fusing tin with charcoal-powder and glacial acid of phosphorus, care must be taken to regulate the fire properly for the phosphorus easily abandons the metal.

EXPERIMENT VI.

Tin is soluble in sulphuric acid.

Put into a matrass five parts of concentrated sulphuric acid and one part of tin in grains; place the vessel on a sand-bath and the tin will dissolve without any effervescence; sulphuric acid will be disengaged, and sulphur will be formed, which remains liquid at the surface of the solution while warm, but precipitates when it cools.

This solution is of a dark brown colour when first prepared but becomes transparent by rest.

If it be long exposed to heat the tin is precipitated in the form of a white oxid.

This solution furnishes crystals in fine needles interwoven with each other, called *sulphate of tin*.

EXPERIMENT VII.

Tin is soluble in muriatic acid.

Put one part of tin into a matrass, pour over it two of concentrated muriatic acid, and place the vessel on a sand-bath; hydrogen gas will be evolved, and a solution of a light amber colour will remain in the matrass.

If the solution be evaporated, brilliant and very regular crystals will be obtained, which are *muriate of tin*.

EXPERIMENT VIII.

Tin is soluble in nitro-muriatic acid.

Put two parts of nitro-muriatic acid into a Florence flask, add gradually one part of tin; if the heat be too great, the vessel must be plunged into cold water to diminish it. This solution is of a reddish brown colour, and often forms in a few moments a viscous trembling jelly. If the solution be diluted with about half its weight of water, it becomes concrete, and is of an opal colour.

EXPERIMENT IX.

Tin decomposes muriate of ammonia.

Take equal parts of granulated tin and muriate of ammonia, introduce the mixture into a retort, and adapt to it a receiver in the mercurial pneumatic trough. As soon as the retort is heated, a decomposition takes place, the ammonia is disengaged in the form of gas, and the residuum is a *solid muriate of tin*, decomposable by water.

EXPERIMENT XII.

Tin causes nitrate of potash to detonate.

purpose fuse tin in a crucible, and make it sometimes project over it pounded nitrate of potash ex-
try; a deflagration will take place, and a brilliant
will arise. Add a new quantity of nitrate of potash
re detonation ensues; remove the crucible from the
aving separated the contents from it, wash them in
r the liquor which contains the potash of the nitrate,
ainder on the filter will be oxid of tin, mixed with
li rendered caustic by the tin. Care, therefore, must
o wash it well, and a small quantity of acid may be
order to precipitate the oxid of tin.

EXPERIMENT XIII.

ates with oxygenated muriate of potash by percussion.

grains of finely divided tin be mixed with double the
oxygenated muriate of potash, a compound will be
ich detonates loudly by percussion.

EXPERIMENT XIV.

Accension of tin-foil by nitrate of copper.

thinly, on a piece of tin-foil, three or four inches
ne dry nitrate of copper, and wrap it up. No effect
Unfold the tin-foil, and sprinkle the nitrate of
a very little water; wrap it up again as quickly as
ressing down the edges closely. Considerable heat
ith fumes will now be excited; and if the experiment

has been dexterously managed, even light will be evolved. This shows that nitrate of copper has no action on tin till in a strong solution.

REMARK...This is a common experiment, shown by teachers of chemistry, to prove that bodies do not act on each other in a dry state. But there seems to be an error with regard to the action of nitric acid on tin; for nitric acid, freed as much as possible from water, will not act upon tin at all; the action only takes place when the acid is diluted. Hence the rational of this experiment must be sought for in the action of the water on the nitric acid of the nitrate of copper.

EXPERIMENT XV.

Tinning copper vessels.

Vessels of copper, especially when used as kitchen utensils, are usually covered with a thin coat of tin to prevent the copper from oxidating, and to preserve the food which is prepared in them from being mixed with any of that poisonous metal. These vessels are then said to be *tinned*. Their interior surface is scraped very clean with an iron instrument, and rubbed over with muriate of ammonia. The vessel is then heated, and a little pitch thrown into it, and allowed to spread on the surface. Then a bit of tin is applied all over the hot copper, which instantly assumes a silvery whiteness. The intention of the previous steps of the process is to have the surface of the copper perfectly pure and metallic; for tin will not combine with the oxid of copper. The coat of tin thus applied is exceedingly thin. Bayen ascertained, that a pan nine inches in diameter, and three inches three lines in depth, when tinned, only acquired an additional weight of 21 grains. Nor is there any method of making the coat thicker. More tin indeed may be applied, but a moderate heat melts it, and causes it to run off.

EXPERIMENT XVI.

Tinning iron.

Iron is tinned in the following manner: Plates of iron, after being reduced to a proper thickness, are immersed in water acidulated with sulphuric or muriatic acid, in order to clean them compleatly from rust; they are then scoured quite bright, and placed in a pot, or other convenient vessel, filled with melted tin, whose surface is covered with suet, pitch, or resin, to prevent the surface of the tin being oxidated. The plates of iron being then suffered to pass through it, the tin will unite with them so as to cover each side of the plate with a thin white coat. They are then what are called tin-plates.

In the same way stirrups, buckles, bridle-bits, &c. are covered with coats of tin.

EXPERIMENT XVII.

Silvering looking glasses.

Looking glasses are covered on one side with an amalgam of tin and mercury. For that purpose tin-foil is evenly placed on a flat stone, or table; and quicksilver, in which some tin already has been dissolved is poured upon it, and spread with a feather, or bunch of cloth, until its union has brightly lined every part. A plate of glass is then cautiously slid upon it from one end to the other, in such a manner that part of the redundant mercury is driven off, or swept away, before its edge. The remainder is now united to the tin. The glass is then loaded with weights all over, so as to press out still more of the mercury; by inclining now the table this remaining quantity of the superfluous mercury becomes

ANALYSIS OF ORES OF TIN.

In order to analyse the ore called tin-stone, let it be calcined and digested with six of concentrated ~~water~~, for at least six hours. Then decompose the residue with water and filter it. The residue consists of a dense H_2S , add to the solution, dissolved potash as precipitate ensues. Then collect the precipitate by ~~whole~~ on a filter, wash it repeatedly, and when dry by fusing it with half its weight, or less, of charcoal the iron which it contained is wished to be separated precipitated from the solution in sulphuric acid, by triple prussiate of potash.

The ore may be analyzed in the dry way in manner: Let one part of the ore be fused with ~~water~~ and dissolve the mass in a sufficient quantity of ~~water~~ insoluble residue must be several times fused with ~~water~~ of potash, and dissolved in water. The residue, then be dissolved in muriatic acid, must be mingled together, and a solution of carbonate of soda.

LEAD.

PART L.

SECT. I.

NATURAL HISTORY OF LEAD.

metal is found in considerable quantity in many parts of the earth. It is found in nature in different states, seldom if ever in the metallic state. It is found in that of an oxid, red mixed with a portion of iron, clay, and other earths. The colour of this ore is aurora red, resembling red arsenic. It is found in small lumps of an indeterminate figure, and also in small four-sided rhomboidal prisms.

When it is heated with carbonic acid it forms the *sparry lead ore*, so called because it has the texture and crystallization of certain sparries. There are a great many varieties of this kind. It is found mineralized with sulphuric, phosphoric, arsenic, molybdic, and chromic acids. Lastly, lead is found mineralized by sulphur forming a sulphuret of lead which is by far its most abundant ore. This ore which is very common is found in masses and crystals.

The primitive form of its crystals is a cube. Its colour is of a pale grey. It has a considerable metallic lustre, its texture is compact. It stains the fingers, and often feels greasy. It is in general a minute quantity of silver.

must be fused in a blast furnace. The lead is by that means separated, and cast into iron moulds, each of which contains a portion called *a pig of lead*. These pigs are sold under the name of *ore lead*.

To disengage the silver from lead thus obtained, the metal is subjected to the action of the refining furnace. The continual application of a quantity of fresh air which is thrown by means of large bellows upon the fused lead, which is at the same time heated as intensely as possible, oxidizes the lead, and converts it into the yellow scaly oxid, known by the name of *lytharge*.

This scaly oxid being driven off from the surface of the fused metal, as it is formed, leaves the silver alone unaltered at the bottom.

The lytharge is then to be fused in contact with charcoal, that it may assume the properties of metallic lead.

In order to obtain perfectly pure lead, the lead of commerce may be dissolved in pure nitric acid, and the solution be decomposed by adding to it, gradually, a solution of sulphate of soda, so long as a precipitate ensues. This precipitate, which is sulphate of lead, must then be collected on a filter, washed repeatedly in distilled water, and then dried. In order to reduce it to its metallic state, let it be mixed with two or three times its weight of black flux, introduce the mixture into a crucible, and expose it briskly to a red heat.

together. The mixture is pulverized, and placed in a lined crucible, which is to be covered. The heat of a forge-furnace is then sufficient to effect the reduction of the metal, which is generally done in the course of half an hour.

The moist or humid way of assaying the ores of iron, is attended with more difficulty. The following method is the most simple. A certain quantity of iron ore is reduced to powder, and digested with about six parts of muriatic acid, which takes up the iron and such earths as are soluble in that acid, and leaves the silex and the sulphur behind; after which, the solution is to be saturated with potash, (or if the ore contains any copper, with ammonia), which precipitates the iron in the state of an *oxid*, along with the dissolved earths; the precipitate is then well dried, and strongly heated to redness, after which, it is pulverized, and put in digestion with diluted nitric acid, which then takes up the earths, together with the other heterogeneous substances, and leaves the iron behind, which, on account of its being highly oxidized, loses its solubility in that acid; it is then washed, freed from the acid, and afterwards recovered by charcoal, or any other inflammable matter which has a strong affinity to the oxygen than the iron; the metal found in the bottom of the crucible, indicates the proportion of the metal contained in a given quantity of the ore.

Arseniate of iron was analyzed by Mr. Chenevix in the following manner: One hundred parts of it were boiled with potash till the arsenic acid was separated. Nitrate of lead was mixed with the solution; 100 parts of the precipitate indicated 33 of arsenic acid. That portion of the ore which eluded the action of the potash was treated with muriatic acid; the undissolved residuum was silex. The muriatic acid was supersaturated with ammonia. The iron precipitated; but the copper was dissolved by the ammonia.*

* Phil. Trans. 1801, p. 219.

COPPER.

PART LII.

SECT. I.

NATURAL HISTORY OF COPPER.

COPPER is found in the earth in various states. It is found native, (*native copper*) possessing the red colour, malleability, and many of its other properties; it is however not quite pure, but generally mixed with a minute portion of gold or silver.

This ore is found of an indeterminate figure, in solid and compact masses; sometimes in plates and threads, which assume a variety of forms. It crystallizes in cubes. It then is flexible. It has much metallic lustre. It is found in many parts of Europe.

Copper ores are very numerous. Copper combined with oxygen forms *oxid of copper*, or the *earthy copper ore*, (*mountain blue*.) United to carbonic acid it constitutes the *hepatic copper ores*, (*mountain green*,) &c. The compact ore of this kind is termed *malachite*.

EXPERIMENT IV.

Copper combines with sulphur both in the wet and in the dry.

(Preparation of sulphuret of copper.)

Take equal quantities of copper filings and sulphur, and forming them into a soft paste, by the addition of a small quantity of water, expose the mixture to the air; lixiviate the end of some days, and sulphate of copper will be formed by crystallizing the lixivium.

A sulphuret of copper may be obtained by putting in a crucible alternate strata of thin plates of copper and sulphur powder. The crucible is then to be exposed to a gradual heat in a furnace, till no more vapours issue from it. Keep the crucible in a dull red heat for an hour, and then suffer it to cool. The product will be a sort of copper slag, brittle, and of an iron colour, which when worked exhibits the colour of the oxide of copper.

EXPERIMENT V.

Copper unites readily with zinc, and forms a compound called brass.

Brass is produced by the following processes: Put into a crucible four parts of granulated copper and twelve of zinc, nearly fill the crucible with charcoal-powder, cover it and heat it briskly to a red heat, the copper will unite with the zinc and form brass.

If plates of copper be cemented with native oxide of zinc reduced to powder, and mixt with charcoal also in powder, bringing the mixture to a red heat in a covered crucible the copper and zinc will unite and likewise form brass.

Brass is made in the large way by a process similar to this.

Phosphate of lead may be dissolved in boiling muriatic acid. The solution is to be diluted with water till the crystals of muriate of lead are dissolved: being then saturated with ammonia, the lead and iron are precipitated. Dissolve the precipitate in muriatic acid, evaporate to dryness, and treat the dry mass with alcohol. The muriate of iron is dissolved; but the muriate of lead remains. Finally, drop lime water into the ammoniacal solution as long as any precipitate appears. That precipitate indicates the proportion of phosphoric acid.

Arseniate of lead has not been analyzed. It might be treated with an alkali, which would separate the lead. This metallic precipitate is then to be re-dissolved in nitric acid, and analyzed by the methods above described. The alkaline arseniate may be dissolved in water, and treated with nitrate of lead; 100 parts of the dry precipitate will indicate 33 of lead.

The sulphurated lead ores or *galenas*, may likewise be analyzed by first depriving them of the sulphur by torrefaction, and afterwards fusing them with two parts of black flux and half a part of iron filings, in a covered crucible, for half an hour; by this means the iron takes up the remaining sulphur; the alkali of the flux promotes the fusion, while its carbon carries off the oxygen; and thus the metal is recovered.

In order to obtain pure lead, let the lead of commerce be dissolved in nitric acid, and precipitate it by means of sulphate of soda. The precipitate, which is a sulphate of lead, after being washed, may be reduced in a crucible, by fusing it with three times its weight of black flux.

IRON.

PART LI.

SECT. I.

NATURAL HISTORY OF IRON.

OF all the metals there is none which is so copiously and variously dispersed through nature as iron. In animals, in vegetables, and in all parts of the mineral kingdom we detect its presence. Mineralogists are not agreed with respect to the existence of native iron, though immense masses of it have been discovered, which could not have been the products of art; there is much in favour of the notion that these specimens have been extracted by subterraneous fire. A mass of native iron, of 1600 pounds weight, was found by Pallas, on the river Denisei, in Siberia; and another mass of 300 pounds was found in Paraguay, of which specimens have been distributed every where. A piece of native iron, of two pounds weight, has been also met with at Kamsdorf, in the territories of Neustadt, which is still preserved there. These masses evidently did not originate in the places where they were found.

There are a vast variety of iron ores; they may, however, be arranged under the following genera; namely, sulphurets, carburets, oxids, and salts of iron. The sulphurets of iron form ores called *pyrites*, of which there are many varieties. Their colour is, in general, a straw-yellow, with a metallic lustre. They are often amorphous, and often also crystallized. Iron in this state of a carburet, forms the *graphite* of Werner, (*plumbeo*). This mineral occurs in kidney-form lumps of various sizes. Its colour is a dark iron-grey, or brownish black; when ~~it~~, blueish grey. It has a metallic lustre. Its texture is fine grained. It is very brittle. The combination of iron with oxygen is very abundant. The common *magnetic iron stone*, *magetical pyrites*, or *load-stone*, belongs to this class: As does *cular iron ore*, and all the different ores called *hematites*, or *red-stone*. Iron, combined with silex, constitutes *emery*. Iron, united to carbonic acid, exists in the *sparry iron ore*. United to arsenic acid it exists in the ores called *arseniate of iron*, *arseniate of iron and copper*.

PROPERTIES OF IRON.

Iron is distinguished from every other metal by its magnetical properties. It is attracted by the magnet, and acquires, under various conditions, the property of magnetism. Pure iron is of whitish grey, or rather blueish colour, very slightly livid; but when polished, it has a great deal of brilliancy. Its texture is either fibrous, fine grained, or in dense plates. Its specific gravity varies from 7.6 to 7.8. It is the hardest and most elastic of all the metals. It is extremely ductile, and may therefore be drawn into wire as fine as a human hair. It is also more tenacious than any other metal, and consequently yields with equal facility to pressure. It is extremely infusible, and when not in contact with the fuel it cannot be melted by the heat which any furnace can excite; it is, however, softened by heat, still pre-

masses. The colour of native silver is white, often tannish. Silver alloyed with gold forms the *auriferous native silver*. The colour of this ore is a yellowish white. It has much metallic lustre. The *antimoniated silver ore* belongs to this class. Silver combined with sulphur, forms the *sulphurated silver*, or *vitreous silver ore*. This ore occurs in masses, sometimes in threads, and sometimes crystallized in cubes or octahedra. Its colour is dark bluish grey, inclining to black. Its fracture is uneven, and its lustre metallic. It is soft enough to be cut with a knife. It is sometimes found alloyed with tin (grey silver ore.) Silver united to muriatic acid forms the *corneous silver ore* (*muriate of silver*), which appears in different colours and shapes. Silver united to oxygen constitutes the *calciform silver ore*, of which there are several varieties. The colour of these ores is a lead-grey, or greyish black. They are massive, disseminated, and crystallized.

Germany, and other countries of Europe, but more especially Peru and Mexico in South America, contain the principal silver mines. There are, however, silver mines in Ireland, Norway, France, and many other parts of the world.

PROPERTIES OF SILVER.

Pure silver is very brilliant, white and sonorous. It is the most splendid of all the metals. Its specific gravity is 10.474 to 11.091 according to the state of its density. It is exceedingly ductile and tenacious. It may be beat out to leaves only $\frac{1}{50000}$ part of an inch thick, and drawn into wires the thousandth part of an inch thick. It melts at 25° of V. wood's pyrometer. Exposed to a temperature considerably higher it becomes volatilized. Atmospheric air has no effect upon it except when it contains sulphureous vapours, sulphur or phosphorated hydrogen gases. It unites to phosphorus and sulphur. It slightly unites with the brittle acidifiable metals.

the other species of iron tarnish in the same situation. It first becomes of a straw-yellow, then of a higher yellow, next purple, then violet, next red, then deep blue, and at last bright blue. At this period it becomes red-hot, and the colours disappear, at the same time that the metallic scales, or the black imperfect oxid of iron which is formed incrust its surface. All these different shades of colour indicate the different tempers the steel has acquired by the increase of heat. Mr. Stodart has availed himself of this property to give to surgical, and other cutting instruments, those degrees of temper which their various uses require, and his attention to this circumstance has rendered his tools so justly celebrated.

Steel possesses a degree of hardness superior to any other metal. It affords sparks with flint. It may be hammered out into much thinner plates than iron, and is more sonorous. It is also possessed of the greatest elasticity, and is perhaps the most useful of all metals.

METHODS OF CONVERTING IRON INTO STEEL.

To form steel, bars of malleable iron are bedded in charcoal in a close furnace, alternate layers of iron and charcoal being formed. A strong fire is applied for six or eight days; the progress of cementation, as this process is termed, is known by drawing a trial bar from the furnace: if this is sufficiently changed the fire is extinguished, and the metal left to cool for some days. This forms *blistered steel*. It is rendered more perfect by subjecting it to the operation of the hammer, as in forging iron; or it is fused, and cast into small bars, forming what is termed *cast steel*. These operations are performed on malleable iron; but those kinds of cast iron which contain little oxygen can be converted into steel by a similar process.

In this operation an increase of weight from $\frac{1}{150}$ th. to $\frac{1}{250}$ th. is gained. The more carbon is introduced the more brittle is the steel. Bergman first showed clearly the presence of this mat-

ter, ascertaining by experiments that less hydrogen gas is disengaged during the solution of steel in diluted sulphuric acid, than during the solution of iron in the same acid; and that during the solution of the steel, carbon is precipitated in the form of plumbago. Morveau has justly observed that it is pure carbon, ~~and~~ its oxid that is present in steel, and to this its great hardness may be ascribed. Bergman further found, that some species of steel contained manganese and silex; and Vauquelin likewise discovered the existence of this earth, and of phosphorus in several kinds of steel which he analyzed.

CLOUET'S METHOD OF MAKING CAST STEEL

A new method of preparing cast steel has been lately announced in France by Clouet. His process is the following: Take small pieces of iron and place them in a crucible, with a mixture of carbonate of lime and the earth of Hessian crucible; six parts of the carbonate of lime and six of this earth must be employed for twenty parts of the iron. The matters are to be disposed, that after fusion, the iron must be completely covered by them, to prevent it from coming into contact with the external air. The mixture is then to be gradually heated and at last exposed to a heat capable of melting iron. If the fire be well kept up, an hour will generally be sufficient to convert two pounds of iron into excellent and exceedingly hard steel capable of being forged; an advantage not possessed by steel made in the common manner.*

Metallurgy therefore comprehends three arts relative to iron, namely, its first fusion into crude iron; the change of this into bar-iron; and its conversion into steel.

The cause of the difference between crude iron, malleable iron, and steel, consists partly in this; that this metal may still

* Phil. Mag. vol. II. p. 219.

and finishing with the silver; cover the crucible, place it among burning coals and bring it to a red heat as speedily as possible. The two substances will thus be combined, and the result is a mass of a dark violet colour, much more fusible than silver, brittle and disposed in needles. This is *sulphuret of silver*.

EXPERIMENT III.

Silver enters into combination with sulphuret of potash in the dry way.

Fuse together, in a crucible, one part of silver and four of sulphuret of potash; stir the mixture frequently and when it is well fused, pour it on a smooth stone, which has been rubbed with a little grease.

This compound is soluble in water and the combination of the silver with the sulphuret is so intimate that it will pass through bilious paper.

EXPERIMENT IV.

Silver unites to mercury with great facility.

Triturate in a marble mortar, one part of silver leaf and seven of mercury; the product will be an alloy which has but little consistence.

A similar combination may be effected by using silver filings; but in that case the trituration must be made in a warm mortar.

REMARKS... This amalgam assumes a regular form by fusion and cooling slowly.

The mercury acquires a degree of fixity in this sort of combination; for it requires a much greater heat to separate it from the silver, than is necessary to volatilize it alone.

EXPERIMENT V.

Silver decomposes concentrated sulphuric acid, at a boiling heat.

Put one part of silver filings into a retort, pour over it in of concentrated sulphuric acid and heat the mixture over a lamp; the acid will be decomposed and sulphureous acid gas will be obtained. The residue in the retort is *sulphate of silver*, which by solution in a large quantity of boiling water, and evaporation, may be obtained in the form of small needle-shaped crystals.

EXPERIMENT VI.

Silver is dissolved by nitric acid, with great rapidity.

Pour nitric acid of a moderate strength, upon some silver in a Florence flask; an effervescence will take place, the metal will be dissolved and nitrous gas will be liberated copiously. If both the silver and acid were perfectly pure, the solution will be colourless, but if otherwise, it will have a milky or greenish hue. If the solution be evaporated it shoots into tabular or scaly crystals, called *nitrate of silver*.

REMARK...A solution of nitrate of silver, stains animal and vegetable substances a deep black; and the colour produced is exceedingly permanent, hence it has been applied for the staining of human hair; but when thus made use of, it should be very much diluted, and used with great caution, on account of its corrosive property.

The article known by the name of *indelible, or permanent marking ink* for marking linen, wearing apparel, &c. consists of a solution of nitrate of silver, thickened with a little gum arabic.

The fluid known by the name of *silver-test*, for detecting counterfeit silver coin is a solution of standard silver considerably diluted.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF IRON.

EXPERIMENT I.

Iron combines with sulphur by heat.

MIX one part of iron filings with two of sulphur, and fuse the mixture in a covered crucible as quickly as possible. The product will be *sulphuret of iron*, which is of a black, or very deep grey colour, brittle, and remarkably hard.

Sulphuret of iron may also be formed by applying a roll of sulphur to the end of an iron bar brought to a white heat; both of them will be fused, and the sulphuret will fall down in drops.

When sulphuret of iron is reduced to powder, and moistened with water, the sulphur is gradually converted into sulphuric acid by absorbing oxygen, while at the same time the iron becomes oxidated. (See vol. I. p. 227).

EXPERIMENT II.

Iron enters into combination with phosphorus.

Mix equal parts of iron filings, and glacial acid of phosphorus, and fuse the mixture in a covered crucible, with half a part of

paration is so hazardous, that it is not to be safely attempted without a mask with strong glass eyes upon the face. No more than a single grain will admit of exhibiting its effect, and even that quantity must be approached with caution. A larger portion cannot be exploded without imminent danger.

RATIONAL... The detonation of this compound is to be ascribed to the hydrogen of the ammonia suddenly combining with the oxygen of the metallic oxid, and forming aqueous vapour which is disengaged with the nitrogen gas; the elasticity of both the gases is augmented by the caloric which is disengaged. No explanation has yet been given why its force is so much greater than that of fulminating gold; but it is probably owing to the silver when in the state of an oxid containing more oxygen than the gold, and to this oxid combining with a larger portion of ammonia; hence, in the sudden combination, more aqueous vapour and nitrogen gas will be disengaged.

REMARK... If the fluid which is separated from the precipitate be slowly evaporated, crystals are formed which explode more violently than the precipitate; a few grains of them cannot be touched without hazard of life.

EXPERIMENT IX.

Preparation of hyper-oxygenated muriate of silver.

(Chenevix's fulminating silver.)

Mr. Chenevix has lately invented a fulminating silver which is more safe than the former; for it explodes only by a slight friction in contact with combustible bodies. It may be prepared in the following manner:

Diffuse a quantity of alumine through water, and let a current of oxygenated muriatic acid gas pass through it for some time. Then digest some phosphate of silver (obtained by pouring a solution of phosphate of soda into a solution of nitri-

ver) on the solution of the oxygenated muriate of alumine, vaporate it slowly. The product obtained will be a hyper-nated muriate of silver; a single grain of which, in contact with two or three of sulphur, will explode violently by the least friction.

EXPERIMENT X.

Arbor Dianæ.

most metallic substances are capable of decomposing a nitric acid of silver. The separation of this metal by mercury, on account of the phenomena which it presents has been called 's tree, or *Arbor Dianæ*:

According to Lemery, dissolve one part of fine silver in weak nitric acid to saturation, and, having diluted this solution with twenty parts of distilled water, add two parts of mercury. Römer's method is to make an alloy in the cold, of four parts silver-leaf and two parts of mercury; to dissolve this alloy in a sufficient quantity of nitric acid, and to add to the solution distilled water.

we put into this liquor a small ball of a soft alloy of silver, the precipitation of the silver immediately takes place.

Imé gives the following process, which will be attended with more success:

Mix together six parts of a solution of silver and four of a solution of mercury, both made with the nitric acid, and completely saturated; add to them a little distilled water, and put the mixture into a conical vessel, into which have been previously introduced six parts of an alloy made of seven parts of mercury and one of silver.

At the end of some hours there will be formed, at the surface of the small mass of alloy, a vegetation in the form of a bush. This process which succeeds better than any of the former, is to mix three drachms and 48 grains of pure silver and half as much mercury, separately, in a sufficient quantity of pure nitric acid.

acid. Mix the solutions, and add to them five or six ounces of distilled water. This must be poured upon seven drachmas of 12 grains of an amalgam of silver of the consistence of brim which had been previously put into a spherical vessel of glass. The vessel must be kept undisturbed, and in about hours a very beautiful silver-tree will be formed.

RATIONALE... The mercury contained in the solution exceeds that of the amalgam; the silver contained in the latter accumulates on that which is held in solution; and the result of these situations is a speedier precipitation of the silver. The mercury which makes part of the amalgam, being more abundant than would be necessary for precipitating the silver of the solution produces also a third effect, which is, that it attracts the silver by the affinity and tendency it has to combine itself with the metal.

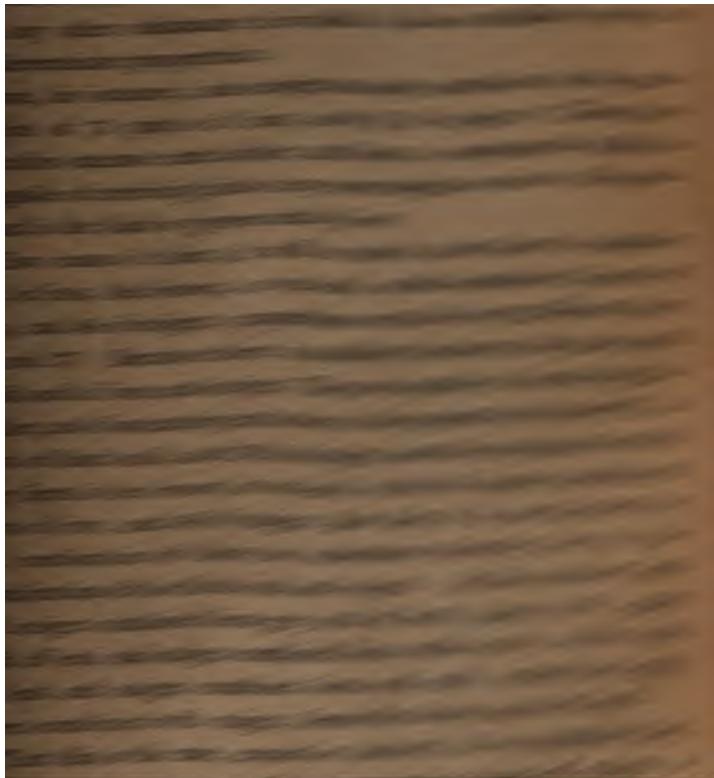
REMARK... In order to obtain a beautiful vegetation, it is absolutely necessary that all the ingredients be of the utmost purity. A cylindrical or conical glass vessel is best suited for it.

EXPERIMENT XI.

Precipitation of silver by copper.

(Vegetation of silver on glass, slate, &c.)

Spread a few drops of a solution of silver in nitric acid, on a smooth piece of slate, or on a plate of glass, by means of a camel's-hair-pencil or feather; place at the bottom of it, in contact with the fluid, a copper or brass wire of about one sixteenth of an inch in diameter, and let the whole remain undisturbed in a horizontal position: in a short period of time it will begin to vegetate. Then with a pencil draw a fluid stroke to any part of the glass or slate, in order to represent the body of a tree,



obtained by making steam pass through a red-hot iron by burning iron in oxygen gas, or by decomposing a sulphide of iron by the addition of potash, and drying the product expeditiously in a close vessel.

The red, or brown, acid of iron, may also be formed by heating red-hot iron in an open crucible, and agitating it restlessly, till they are converted into a dark, red powder called magnetite, or iron, or magnetized magnetic acid.

It may also be prepared by exposing a solution of ferrous acid, for a long time to the atmosphere, a process known as *oxidation*, or *oxidized magnetic acid*.

However... We are indebted to Priest for an account concerning the combination of oxygen with iron; it has been noted in a very remarkable manner, that an oxygenic substance degrees of oxidation, the only number, and that every particular acid consists of a quantity of the metal, and oxygen chemically combining.

The metal under consideration, like iron, is not very readily exposed, or oxidized with oxygen in a moderate degree, between 600°, and 800°.

Iron, and similar salts, previously dried perfectly, are subject to such a penetrating and destructive decomposition, after the usual combinations, as follows:

2000

ing into it a plate of iron. When the ore contains no proportion may be estimated by weighing before and after for the arsenic is dissipated by heat: or the ore may be boiled as before in nitric acid, which acidifies the arsenic. At separation of the silver, the arsenic acid may be precipitated by lead, 100 parts of the dry precipitate in about 22 of arsenic.

Sulphuret of silver is to be treated with diluted nitric acid which dissolves the silver, leaving the greater part of the sulphur untouched. The residuum is to be dried, and then the sulphur burnt off. The loss of weight gives the sulphur. The silver may be precipitated by common salt; and the other metals, if present, may be ascertained as above. Part of the sulphur may always be acidified. The acid thus formed may be precipitated by the nitrate of barytes, 100 parts of the dried precipitate in about 14.5 of sulphur.

Antimoniated silver ore was analyzed by Klaproth in the following manner: 100 parts of it were boiled in dilute nitric acid. The residuum, washed and dried, was 26. This was digested in nitro-muriatic acid. The residuum now weighed 13 (so that 13 had been dissolved), 12 of which were washed and burnt away, leaving behind them one part of silver. The nitro-muriatic solution, when diluted largely with water, gave a precipitate which weighed 13 (or 10 of pure antimony) and had the properties of oxid of antimony; for they did not ignite till heated to redness, but at that temperature were volatilized in a grey smoke.

The nitric solution was green. Common salt occasioned a precipitate which weighed 87.75, equivalent to 65.81 of silver. After the separation of this muriate of silver, sulphuric acid occasioned no precipitate. Therefore the solution contained lead. When supersaturated with soda, a grey precipitate weighing 5 parts. On burning coals this precipitate gave an arsenical smell. It was re-dissolved in nitric acid; sulphuric acid occasioned a smutty brown precipitate; and Prussian

Russian blue, which, after torrefaction, was magnetic. He concluded, that these 5 parts were a combination of silver and arsenic acid.*

Red silver ore was analyzed by Vauquelin in the following manner: One hundred parts of it were digested in 500 parts of nitric acid previously diluted with water.† The undissolved residuum, being washed and dried, weighed 42.06. Being treated with muriatic acid, it was all dissolved except 14.66 parts, which were sulphur. The muriatic solution, when diluted with a great quantity of water, deposited a white powder, which weighed 21.25, and was oxid of antimony. The nitric solution remained still to be examined. Muriatic acid occasioned a heavy precipitate, which was muriate of silver. Reagents showed that the acid retained no other substance in solution.‡

Muriate of silver was analyzed by Klaproth in the following manner: One hundred parts of it were mixed with thrice their weight of pure carbonate of potash, and melted together in a glass retort. The mass was dissolved in water, and the solution filtered. A residuum remained, which was dissolved in nitric acid, with the exception of a red powder, which, treated with nitro-muriatic acid, was dissolved, except a little muriate of silver, which, when reduced, yielded .5 of pure silver. Ammonium was precipitated from the nitro-muriatic solution 2.5 parts of iron. The nitric solution was precipitated by common salt; the muriate of silver, thus obtained, yielded, when reduced, 2.5 of pure silver.

The original aqueous solution of the alkaline mass was saturated with acetoos acid, on which it deposited 1.75 parts of alum. The solution was evaporated to dryness, and the dry mass dissolved with alcohol, which dissolved the acetite of potash. The

* Klaproth's Beiträge i. 163.

No effervescence occurred during the solution; a proof that the metals existed in the ore in the state of oxids.

† Journ. de Min. No. xvii. p. 2.

arsenic acid, &c. Copper mineralized with vitreous copper ore. Its colour is generally tincted with sulphur and iron it forms the *azure* of the varieties of copper pyrites. Mineralized with zinc, iron, and zinc, it constitutes the *brown* or *black* *ores*, of which there are many varieties. Copper is abundant in Britain, Germany, &c.

PROPERTIES OF COPPER.

Pure copper is of a rose-red colour, very sonorous, ductile, and malleable; of a considerate moderate hard and elastic. Its texture is granular, subject to blisters. It crystallizes in quadrilaterals. Its specific gravity is between 7.788 and 8.584. It emits a disagreeable odour. It melts at 27° in a pyrometer. At a higher temperature it burns with a beautiful green flame. It is a good conductor of calor and of galvanism. Exposed to the air it becomes green by absorbing carbonic acid. When heated it becomes blue, yellow, violet and brown. It readily fuses and unites to sulphur when finely divided by

merely in vitrification. Liquid ammonia causes it to oxidise quickly when air is admitted. It decomposes muriate of ammonia and red sulphurated oxid of mercury by heat. It is poisonous to the human constitution.

METHOD OF OBTAINING COPPER.

Copper is procured from its ores by different processes according to the nature of those ores. If they contain much sulphur, after being pounded and washed, they are roasted in the open air to dispel the sulphur. The ore is afterwards roasted once or twice more, and is melted in an open fire into a mass, called a mat of copper. In this state it still contains a large quantity of sulphur, which the workmen continue to expel by repeated roastings and fusion, till the metal acquires a certain degree of purity, and is called black copper, which is somewhat malleable, but still contains sulphur, iron, and in general some other impurities. In order to get entirely rid of these, the copper is hastily fused with three times its weight of lead. The lead unites with the copper and expels the iron; and the rest of the metals which happen to be mixed with the copper are thus expelled. The copper is afterwards refined by keeping it heated in crucibles for a considerable time, so that it may throw up all the foreign substances it still contains in the form of scoriae. It is examined from time to time by immersing iron rods into it, which become coloured with a small quantity of copper, and its purity is judged of by the brilliant redness of these specimens.

Take equal quantities of copper filings and a
long firmed them into a soft paste, by the addition
of quantity of water, expose the mixture to the
air the end of some days, and sulphate of copper
will crystallise the Lantum.

A sulphate of copper may be obtained by
crushing diamant stones of thin plates of copper
powder. The crucible is then to be exposed to
the air, till no more vapour issue from it,
and in a dull red heat fire on horse, and there on
this product will be a sort of copper slate, but
more porous, which when worked exhibits the
metal of copper.

EXPERIMENT V.

Copper water reddish with lime, and different
colours with lime.

Some is prepared by the following process. Take
two fine parts of powdered copper and lime
and mix the crucible well together, and
it should be red colour, the copper and lime

tin is obtained in a like manner by fusing together in a
of twelve parts of copper and three of zinc.

metall is said to consist of copper alloyed with one tenth
tin.

metall is copper alloyed with about one-sixth of tin; it
will generally be observed that a less proportion of tin is used
in church-bells than clock-bells, and that a little zinc
is used for the bells of repeating watches, and other small bells.
metall of which cocks are in general made is copper al-
loyed with zinc and lead.

EXPERIMENT VI.

*Concentrated sulphuric acid only acts upon copper at elevated
temperatures.*

upon one ounce of copper filings in a muriass, two
of concentrated sulphuric acid, there will be no action in
it; but if the muriass be placed on a sand-bath, and a de-
ficient heat applied nearly sufficient to make the acid boil, the
will be gradually dissolved and sulphurous acid gas will
be evolved.

EXPERIMENT VII.

When gold is in a state nearly pure, (*native gold*) as it is found dispersed among stones, or mixed with sand, it may first be reduced to small granular pieces, together with the matrix; a table of several feet long, and one and a half broad, with ledge round three of its sides, and pieces of cloth with a long nail on the board, is placed under a gentle stream of water upon which the pounded ore or sand is thrown; by this contrivance, the lighter and heterogeneous substances are washed off.

When the stuff or cloth is sufficiently charged with the particles of gold which adhere to it, on account of its superior gravity, it is disengaged from the board, and put into a vessel, where it is further agitated with water, and more freed from the lighter substances. It is then mixed with $\frac{1}{10}$ of mercury, and triturated in an iron or copper vessel containing boiling water, until the mercury has absorbed all the gold particles. The mercury containing the gold in solution, is to be separated, first from the water, next from the earthy particles, and then from the sand, by throwing the whole upon a table placed in an incline direction; the mercury charged with gold, but still vivid, will when assisted by a little stirring, or manipulation, run off the table, and leave the sand behind. The mercury is then separated from the gold, (and silver if any) by exposing the all in earthen retorts to such a heat as will occasion the mercury to distill off, and is collected again in a receiver with water. The gold not being volatile in fire, is thus left behind, and afterwards further freed from the heterogeneous imperfect metallic substances, by the process of cupellation.

After these processes, the silver, if the gold contains any, is separated by reducing it first to very fine laminæ, and then extracting the silver by nitric acid, which leaves the gold behind. The silver may be separated from the nitric acid, by muriatic acid, with which it forms muriate of silver. Muriate of silver is to be decomposed again, by mixing it with soda, and exp

ing it to a sufficient heat in a crucible, whereby the soda unites to the muriatic acid, and sets the silver free.

When gold is found mixed with sulphur or arsenic, and other metals, the ore must first be torrefied; which separates the greatest part of the arsenic and sulphur, and then melted with iron, which unites with what remains. The heterogeneous metallic substances are then separated by scorification with fluxes, consisting of tartrite of potash and nitrate of potash, which have no effect upon gold when the sulphur is previously separated; without this previous separation, the sulphur would unite with part of the alcali of the nitrate of potash, and form sulphuret of potash, which would take up a portion of the gold, and thus diminish the produce. The gold left by the melting with the flux, is afterwards further purified by cupellation, or melting with lead.

When the gold ore is free from sulphur, it may after being pounded and washed, be melted with one and a half part of semi-vitreous oxid of lead, and three parts of glass, in a crucible covered with muriate of soda. By this operation, all the heterogeneous metals will scoria, and set the gold free.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF GOLD.

EXPERIMENT I.

Gold is not acted on by any acid, the oxygenated muriatic and nitro-muriatic acid excepted.

INTRODUCE some gold-leaf into any acid, no solution will be effected by it; but if oxygenated muriatic acid, or nitro-muriatic acid, be made use of, a solution will be effected. If the gold-leaf be exposed to the action of the oxygenated muriatic acid in its gaseous state, it takes fire. (See vol. i. p. 33.)

A saturated solution of gold in these acids yields, by evaporation, crystals of muriate of gold, of a beautiful yellow colour, not unlike *topazes*; they consist sometimes of truncated octahedra, sometimes of tetrahedral prisms. When dissolved in water they tinge the skin indelibly of a deep purple colour, and produce the same effect upon almost all animal and vegetable bodies, and even upon marble.

RATIONALE.—The gold robs the acid of part of its oxygen, and becomes oxidated; the oxygenated muriatic acid, or the nitro-muriatic acid, is converted into simple muriatic acid, in which state it is capable of dissolving the oxid of gold, and constitutes with it *muriate of gold*.

REMARK....Though nitro-muriatic, or more properly oxygenated muriatic acid, is the only fluid capable of dissolving gold, it has been long ago noticed that nitrous acid, assisted by heat, exercised some slight action on this metal, especially when in a state of extreme comminution.

EXPERIMENT II.

Gold is precipitated from its solution by tin.

(Preparation of the purple precipitate of Cassius.)

If we immerse into a solution of gold in nitro-muriatic acid a sheet of tin, the oxid of gold is precipitated of a purple colour, and, when scraped off and collected, forms the purple powder, or precipitate of Cassius, much employed in enamelling. It is a compound, consisting of oxid of gold and oxid of tin. It is best obtained, for the purpose of enamelling, by dissolving pure tin in diluted nitro-muriatic acid, composed of two parts of nitric and one of muriatic acid, very slowly, and absolutely without heat, and then adding to this fresh-prepared solution, diluted with at least eighty times its weight of distilled water, a solution of pure gold in nitro-muriatic acid, collecting the precipitate, and washing it repeatedly with distilled water.

REMARK....It is absolutely necessary that the tin should be oxidated at its *minimum*, for the oxi-muriate of tin, which is already at a *maximum* of oxidation produces no such effect, because it cannot abstract oxygen from the oxid of gold.

EXPERIMENT III.

Gold is precipitated from its solution by charcoal.

Into a perfectly neutral diluted solution of gold, contained in a glass jar, put a long narrow slip of well-burnt charcoal, and

expose it to the direct rays of the sun ; the gold will be revived and appear on the charcoal in a metallic state, exhibiting a very beautiful appearance. The same effect will be produced, without light, by boiling the charcoal in the solution for a few minutes.

EXPERIMENT IV.

Gold is also precipitated by ether, essential oils, &c.

If highly-rectified ether, or a pure essential oil, be shaken together with a solution of gold, the gold will be precipitated, but it will be instantly dissolved by the ether or oil, and form with the first an *etherial solution of gold*, which is of a golden-yellow colour, and floats on the top of the fluid.

If the solution be evaporated the gold is obtained in a state of absolute purity.

REMARK...Gold thus dissolved was formerly called *potable gold*. It was anciently employed in medicine. The apothecaries made their patients supply the gold, and pretended that the purer the gold, so much the speedier would be the cure. But these errors have been long exploded.

EXPERIMENT V.

Decomposition of nitro-muriate of gold by hydrogen or sulphureous acid gas.

For these facts we are indebted to Mrs. Fulham. She found, that if a white sattin ribbon be moistened with a diluted solution of gold in nitro-muriatic acid, and then exposed, while moist, to a current of hydrogen gas, the gold would be reduced, and the ribbon become gilt with the metal. But if the silk be dried previously, the reduction does not take place. By

means of a camel-hair pencil, the gold may be so applied as to exhibit regular ornaments, or figures, when reduced.

The same reduction takes place when the silk is dipped into phosphorated ether. If a piece of silk, moistened with phosphorated ether, be immersed in the nitro-muriatic solution, its surface is immediately gilt with a fine coat of gold, which adheres very strongly.

That phosphorated hydrogen gas produces the same effect has been noticed already, (vol. i. p. 276). Sulphureous acid gas has a similar effect.

REMARK.—Mrs. Fulhame has proved* that the presence of moisture is absolutely necessary for the reduction of gold. It is difficult to ascertain what makes water so indispensably necessary. It is not, as might be supposed, requisite to secure the fluidity of the mixture; for she has ascertained that sulphuric ether, though a fluid, does not answer, except water be present. She accounts very ingeniously for the phenomena, by supposing the water to be decomposed. The combustible combines with its oxygen, while its hydrogen unites to the oxygen of the gold, and re-produces water. This theory accounts very well for the phenomena; but it would require some direct proofs to establish it completely.

EXPERIMENT VI.

Decomposition of nitro-muriate of gold by ammonia.

(Preparation of fulminating gold.)

Dissolve pure gold in nitro-muriatic acid to saturation, and dilute the solution with three times its bulk of distilled water, and add to it gradually some pure ammonia, a yellow precipitate

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* In her *Essay on Combustion*.

EXPERIMENT XI.

Gold unites with alkaline sulphurets both in the dry and humid way.

To exhibit this, some leaf-gold may be digested with heat in a solution of sulphuret of potash. Or,

Equal parts of sulphur and potash may be fused quickly with gold-leaf.

REMARK...Some chemists have persuaded themselves that this was the process made use of by Moses to render the Golden Calf, which the Israelites cast in that metal and set up in the wilderness, to worship during Moses's absence on the Mount, potable, which, as related in Exod. XXXII. that legislator ground to powder, burnt, and mixt with the water the people were to drink. There is however nothing related concerning the operations necessary for that purpose.

GILDING,

Or the art of covering the surfaces of bodies with gold. Manufacturers use the term improperly to denote silvering, as well as gilding, and likewise the various methods of producing a golden colour without actually using gold.

The real application of gold, as a covering, may be performed, either by a metallic mixture after the manner of a pigment; or by friction, upon the same principle as black-lead, and coloured chalks are used; or by the chemical precipitation of gold from mercury, or some other fit solvent; or, lastly, by glueing, or fastening extremely thin leaves of gold, to the surface intended to be gilt.

Shell-gold, or gold-powder

For painting, may be obtained by uniting one part of gold with eight of mercury, and afterwards evaporating the latter by heat, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration, as mentioned already under the article *shell-silver*.

Cold gilding by friction.

Steep a fine linen rag in a saturated solution of gold, till it has entirely imbibed the fluid; this rag must then be dried over a fire, and afterwards burnt to tinder. When any thing is to be gilt, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterwards into the black powder; and the piece, after being rubbed with it, must be burnished. This powder is frequently used for gilding delicate articles of silver.

Gilding of brass or copper.

Fine instruments of brass, in order that their surface may be kept longer clean, may be gilt by immersing them several times in a solution of muriate of gold, free from excess of acid, and afterwards burnishing them.

Water-gilding.

This term was probably at first confined to such processes as demand the use of a solution of gold in nitro-muriatic acid, and means a chemical application of gold to the surfaces of metals. If a solution of gold be copiously diluted with ardent spirit, a piece of clean iron will be gilt by being repeatedly steeped therein.

An improved process for gilding iron or steel.

This method which is less known among artists than it deserves to be, may prove useful to those who have occasion to gild iron or steel.

The first part of the process consists in pouring into a solution of gold in nitro-muriatic acid, about twice as much sulphuric ether. In order to gild iron or steel, the metal must be well polished with the finest emery, or rather with the finest red oxid of iron and spirit of wine. The ether which has taken up the gold is then to be applied with a small brush; it evaporates, and the gold remains on the surface of the metal; the metal may then be put into the fire, and afterwards polished. In this manner all kind of figures may be delineated on iron, by employing a pen or fine brush.

Gilding of iron, by means of heat,

Is performed by cleaning and polishing its surface, and then heating it, till it has acquired a blue colour. When this has been done, the first layer of gold-leaf is put on, slightly burnished down, and exposed to a gentle fire. It is usual to give three such layers, or four at the most, each consisting of a single leaf, for common works; or two for extraordinary ones. The heating is repeated at each layer, and last of all the work is burnished,

Grecian gilding

Is performed in the following manner: Equal parts of muriate of ammonia, and muriate of mercury, are dissolved in nitric acid, and a solution of gold is made in this menstruum; upon this the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but on being exposed to a red heat, it assumes the appearance of gilding.

Method of gilding silver, brass, or copper, by means of an alloy of gold and mercury,

Eight parts of mercury and one of gold, are alloyed together by heating them in a crucible. As soon as the gold is perfectly alloyed, the mixture is poured into cold water, and is then ready for use.

Before the alloy can be laid upon the surface of the metal, this last is brushed over with diluted nitric acid, in which it is of advantage that some mercury may have been dissolved. Some artists then wash the metal in simple water, and scour it a little with the finest sand, previous to the application of the gold; but others apply it to the metal while still wet with the nitric acid. But in either case, the alloy must be laid on as uniformly as possible, and spread very even with a brass wire-brush, wetted from time to time with water. The piece is then laid upon a grate, over a charcoal fire, or in a small oven, or furnace, adapted to this purpose; the heat drives off the mercury, and leaves the gold behind. Its defects are then seen, and may be remedied by successive applications of more amalgam, and additional application of heat. Expert artists however make these additional applications while the piece remains in the furnace, though the practice is said to be highly noxious, on account of the mercurial fumes. After this it is rubbed with gilders wax, which may consist of four ounces of bees wax, one ounce of acetite of copper, and one ounce of sulphate of copper; they then expose it to a red heat, which burns off the wax; and lastly, the work is cleansed with the scratch brush, and burnished, if necessary, with a steel tool. The use of the wax seems to consist merely in covering defects, by the diffusion of a quantity of red oxid of copper, which is left behind after the burning.

Painting with gold upon porcelain, or glass

Is done with the powder of gold which remains behind after driving off the nitro-muriatic acid from a solution of that metal,

... twenty-four parts, called carats, and estimated according to the number of carats up.

Carats of Great Britain are composed of copper, they are therefore gold o

Pure gold may be obtained by dissolving in nitro-muriatic acid, and precipitating with a solution of sulphate of iron. The precipitate, washed and dried, is pure gold.

PART LV.

SECT. L.

NATURAL HISTORY OF PLATINUM.

THUSFAR no stone of platinum has been discovered. It stands in nature, only in a metallic state or small grains, mixed with iron, copper, plumbago, &c. The largest of which we have heard, is one of the size of a pigeon's egg in the possession of the Royal Society of Bengal. It stands in the parishes of Novia and Cawnpore, Bengal, Asia.

METHOD OF OBTAINING PLATINA.

The processes most commonly employed to obtain pure platina, are as follows:

1. Take equal parts of platina in grains, and acidulous tartrite of potash, put the mixture into a well luted crucible, and expose it for two hours to a violent heat. The platina fuses, but it becomes brittle and whiter than platina is in common; then expose it to a very strong heat under a muffle, by which means all the arsenic combined with it will be disengaged, and the platina remain behind in a malleable state.

2. Platina may likewise be obtained pure, by decomposing the nitro-muriatic solution of common platina, by muriate of ammonia, heating the precipitate intensely, and stamping it when of a white heat into one mass: or, by assisting the fusion with a stream of oxygen gas.

3. Jannetty's process, which is considered as the best, and which is generally used for obtaining malleable platina, is as follows:

Triturate common platina with water, to wash off every contaminating matter that water can carry away. Mix the platina with about one-fifth part of arsenious acid and one fifteenth part of potash; putting the whole in a proper crucible, in the following manner: Having well heated the crucible and the furnace receiving it, put in one-third of the mixture, apply to this a strong heat, and add one-third more: after a renewed application of heat, throw in the last portion. After a thorough fusion of the whole, cool and break the mass. Then fuse it a second time, and, if necessary, even a third time, till it ceases to be magnetic. Break it into small pieces, and melt those pieces in separate crucibles, and in portions of a pound and a half of the platina to each crucible, with an equal quantity of arsenious acid and half a pound of potash. After

the oil shall have evaporated to dryness. Then immerse in nitric acid, boil them in water, heat them to redness, cible, and hammer them into a dense mass. They are now heated in a naked fire, and hammered into bars for the of commerce.

Mr. Richter directs, in order to purify platina, and malleable, the following process : Dissolve platina of copper in nitro-muriatic acid; and let fall into this solution potassium until a precipitate begins to appear; then add a solution of potash, till the whole is precipitated. Wash the precipitate, till the water that passes do not change its colour by adding a solution of prussiate of potash. Dry the precipitate, and mix with it twice its weight of soda, freed from its water of crystallization; press it into a crucible, but not so as to fill it, heat it gradually, and raise the heat till it fuses.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF PLATINA.

EXPERIMENT I.

Platina is soluble in nitro-muriatic acid.

IF one part of platina and ten of nitro-muriatic acid be presented to each other a violent action takes place, and the platina becomes dissolved. On evaporating the solution, very small crystals of muriate of platina are deposited.

REMARK... This is the only saline combination of this metal, of which the properties have been examined; it appears that the platina exists in the solution in two states of oxidation. On adding potash to it, a precipitate is formed which is a triple compound of the alcali, acid, and platina highly oxidated; it is sparingly soluble in water and of a saline nature. When more potash is added, another precipitate is thrown down, which is the imperfect oxid of platina.

Ammonia acts in a similar manner on the solution; and the muriate of ammonia likewise forms a triple compound of oxid of platina, muriatic acid, and ammonia, which being insoluble is precipitated. *By this property of affording a precipitate on the addition of muriate of ammonia to its solution, platina is distinguished from every other metal.*

Platina
lour, inter-
hardest of
23, makes
leable, duct-
yet ascertai-
smaller diam-
the most in-
considerable
furnaces, by
the assistance
to combine
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oxid of platini-
nia, muriatic

similar effect is produced by throwing phosphuret of platinon nitrate of potash in a state of fusion.

EXPERIMENT V.

Platina is soluble in potash in the dry way.

potash, prepared according to Berthollet's process, be kept in for some time in a platina crucible. It will be found, that vessel has lost part of its weight, which is dissolved by the alk. For if we dissolve this alkali in water, and saturate solution with muriatic acid, a triple salt will be obtained by evaporation, consisting of platina, muriatic acid, and potash. This fact was first noticed by Mr. Chenevix.*

TANTALITE.

PART LVI.

NATURAL HISTORY OF TANTALITE.

SINCE the printing of the preceding sheets, a new metallic substance has been announced by Mr. Ekeberg, to which he has given the name of *Tantalite*. This metal exists in the mineral called Gadolinite, and also in a species of tin ore, or oxid of tin, (zin-graupen.) In the first of these minerals, tantalite exists combined with oxid of iron and manganese; in the latter it is united to *yttria*; hence the discoverer of this metal has called the latter mineral *yttro-tantalite*. Both are found in considerable abundance in Sweden and Finland.

PROPERTIES OF TANTALITE.

Tantalite is distinguished from all other metals by being insoluble in any of the acids. It is acted on only by alkalies. The solution is decomposeable by a copious addition of acids in excess. The product obtained is of a white colour, which it retains after having been ignited. Its specific gravity is 6,500. It fuses with phosphate of soda and ammonia, or sub-borate of soda.

to a colourless glass. Exposed to a high temperature with charcoal, it agglutinates and acquires a metallic aspect. Its fracture brilliant, and its colour greyish black.

These properties together with its great specific weight have induced Mr. Ekeberg to consider it as a new metal.

The substances with which it might be confounded are the oxids of tin, tungsten, and titanium, all of which are more or less soluble in alkalies, and under certain circumstances resist the action of acids. But it is well known that the oxid of tin is easily reducible, whereas the oxid of tantalite requires an intense heat to reduce it even imperfectly. The oxid of tungsten is soluble in ammonia, but that of tantalite is not. The colour communicated to phosphate of soda and ammonia by fusion with the oxid of titanium is yellow or hyacinth colour, and that of the oxid of tungsten is blue; but oxid of tantalite fuses with these salts into a colourless glass.

Whether this substance will retain its place among the metals, must be left to future investigation, at present we have only the authority of Mr. Ekeberg* for inserting it.

* Journal de Mines, No. 20, An. x, p. 248, and Annales de Chimie, An. x, p. 276.

ENUMERATION OF EARTHS.

EARTHS.

EARTHS.

PART LVII.

ON there seems to be an almost infinite variety of substances scattered on the surface of this globe; yet examine them with a chemical eye, we find, not without, that all the earth and stones which we tread under and which compose the largest rocks, as well as the different specimens which adorn the cabinets of these composed of a very few simple or elementary earths, no more than seven.

ENUMERATION OF EARTHS.

SILEX,	ZIRCON,
ALUMINE,	AGUSTINE,
GLUCINE,	YTTRIA,
MAGNESIA.	

are all the simple earths hitherto known; none of them seen decomposed, nor has the smallest proof been

sought that they are compound; we must therefore consider them as simple bodies, which nature presents to us completely armed, though one or more of them enters into the composition of a great many bodies. They have a variety of properties which are common to all.

GENERAL PHYSICAL PROPERTIES OF EARTHS.

All earths are dry incombustible bodies. They are insoluble in water, and alcohol, or nearly so. They have little or no taste. Their specific gravity does not exceed 4.9. When perfectly pure they assume the form of a white powder, harsh to the touch. They are infusible. They are capable of combining with acids, when they form neutral salts. They are likewise disposed to unite with the alcalies, with sulphur, and phosphorus; with metallic oxids, and with each other, either by fusion or solution in water.

Every one of these characters is not perhaps rigorously applicable to each of these bodies; but they all possess a sufficient number of them to render it useful to arrange them under one class.

Stones differ from earths principally in cohesion and hardness, and therefore are included under the same general name.

PROPERTIES OF SILEX.

Silex when perfectly pure exists in the form of a white powder. It is insipid and inodorous. It is rough to the touch, cuts glass, and scratches or wears away metals. Its specific gravity is about 2.66. It is unalterable by the simple combustible bodies. When mixed with water it does not form a cohesive mass. Its molecules when diffused in water are precipitated with the utmost facility. It is not acted on by any acid, except the fluoric. When in a state of extreme division it is soluble in alkalies; fused with them it forms glass. It melts with the phosphoric and boric acids. It is unchangeable in the air and unalterable by oxygen and the rest of the gaseous fluids. It has been considered as insoluble in water, but it appears when in a state of extreme division to be soluble in a minute quantity.

METHOD OF OBTAINING SILEX.

Silex may be obtained, tolerably pure, from flints, by the following process: Procure some common gun-flints; expose them in a crucible to a red heat, and then plunge them into cold water; by this treatment they will become brittle, and easily reducible to powder. Mix them, when pulverized, with three or four times their weight of carbonate of potash, and let the mixture be fused, in a dull red heat, in a silver crucible. We shall thus obtain a compound of alkali and silex, called siliceous potash. Dissolve this compound in water, filter the solution, and add to it diluted sulphuric or muriatic acid. An immediate precipitation now ensues, and as long as this continues, add fresh portions of acid. Let the precipitate subside; pour off the fluid that floats above it; and wash the precipitate with hot water till it comes off tasteless. This powder when dry is silex.

made of wax; let it stand for a few days and agitate it frequently. On examining the contents the silex will be found to be dissolved in the acid.

EXPERIMENT IV.

Silex is dissolved by alkalies in the humid way, when in a state of extreme division.

This may be proved by boiling one part of pure silex, minutely divided, in a silver vessel with 20 parts by weight of a concentrated solution of potash or soda. The earth will be dissolved, and may be separated again by the addition of an acid.

EXPERIMENT V.

Silex is soluble in alkalies by fusion.

The method of obtaining silex, as mentioned before, furnishes a proof of this.

EXPERIMENT VI.

Silex is fusible with the phosphoric and boracic acids.

Place a few grains of silex and glacial acid of phosphorus or borax, on a bit of charcoal, and urge it by means of the blow-pipe; the mixture will melt and form a globule of transparent glass.

The other properties of this earth may be investigated without any description.

FORMATION OF GLASS.

Glass is obtained by mixing silex with a proper proportion of soda or potash, and exposing this mixture to a violent heat.

When these substances are completely fused and have acquired a certain degree of heat, which is known by the fluidity of the mass, part of the melted matter is taken out at the end of a hollow tube, which is dipped into it, and turned about until a sufficient quantity is taken up; the workman at each turning it gently upon a piece of iron, to unite it more intimately. When he blows through the tube, till the melted mass at the extremity swells like a bubble, after which he rolls it again on a flat surface to polish it, and repeats the blowing, until the bubble is brought as near the size and form of the vessel required, as he thinks necessary.

If it be a common bottle, the melted matter at the end of the tube is put into a mould of the exact size and shape of its body, the neck is formed on the outside by drawing out the ductile

mass, and when it is sufficiently drawn out, it is broken off, and the vessel with a large or wide orifice, the glass in its melted state is opened and widened with an iron tool; after which it is again heated, it is whirled about with a circular motion, and by means of the centrifugal force thus produced is reduced to the size required. Should a handle, foot, or any other part of the vessel be required, these are made separately, and then tuck on in its melted state.

Window-glass is made in a similar manner, except that the glass at the end of the tube is formed into a cylindrical shape, which being cut longitudinally by scissors or shears, is gradually drawn back until it becomes a flat plate.

Large plate-glass for looking-glasses, &c. is made by suffering the glass in a state of complete fusion to flow upon a casting-table, which is supported by iron ledges to confine the melted matter, and as it is flowing a metallic roller is passed over it to reduce it to an uniform thickness. There are different kinds of glass manufactured for different purposes; the principal of these are *flint-glass*, *crown-glass*, and *bottle-glass*.

Flint-glass is the densest, most transparent, colourless, and beautiful. It is often called *crystal*. The best kind is said to be

surface which incarcerates it becomes broken. M on the contrary, maintains an opinion diametrically this: he supposes, that during the sudden cooling vacuities are formed between its particles, and th sealed up by the smooth surface of the external cove on the continuity of that surface being interrupted, denly rushing in occasions the bursting of the drop.

are two toys made of unannealed glass, which though used for the amusement of children, exhibit phenomena which justly interest the curiosity of the philosopher, we may call them Prince Rupert's drop, and the Bologna flask, or philosophical.

Prince Rupert's drop is made by letting drops of melted glass into water; the drop assumes by that means an oval with a tail or neck resembling a retort. These drops are said to have been invented by Prince Rupert, and are therefore called by his name. They possess the singular property, that if a portion of the tail is broken off, the whole bursts into pieces with a kind of explosion, and a considerable shock is communicated to the hand that grasps it. Their explosion is said to be attended with a flash of light, this however is not always the case; a flash of light indeed is produced if the drop be broken in a glass-receiver, but in that case the flash proceeds from the impact of the projected particles, forcibly striking against the glass, but no such phenomenon takes place if the drop be broken in free space.

Bologna, or philosophical phial is a small cylindrical vessel which has been suddenly cooled, open at the upper end, closed at the bottom. It is generally made so thick at the bottom, that it will bear a smart blow against a hard body without breaking, but if a little pebble or piece of flint is let fall into it immediately cracks, and the bottom falls into pieces.

THEORY...Concerning the cause of the phenomena of both these bodies, different opinions have been advanced. The most plausible is founded on the assumption that the dimensions of both are suddenly cooled remain shorter than if the cooling had been more gradual. The dimensions therefore of the external surface of these glasses, which are suddenly cooled are supposed to be shorter than is adapted to the accurate envelopement of the internal part, which is necessarily contracted in a more gradual manner; if therefore by a crack or fissure a solution of the continuity takes place in the external

..... to opinion numerical
during the sudden cooling
when its pressure and
surface of the external cov-
erage being interrupted,
the bursting of the drop.

ALUMINE.

PART LIX.

SECT. I.

NATURAL HISTORY OF ALUMINE.

is earth derives its name from alum, of which it forms the
It constitutes the lower strata of mountains and plains.
sets the water in motion and causes them to rise in springs to the
surface of the earth. It enters into the natural composition of
stones, and all these stones and earths called argillaceous,
or power's-clay, fuller's-earth, lepidolite, mica, corundum,
etc. Hitherto it has not been found pure any where, except
in a small quantity in the garden of the public schools at Halle in Germany.

PROPERTIES OF ALUMINE.

Alumine is white, and soft to the touch. It is insipid, ad-
hesive to the tongue, and occasions a sense of dryness in the
mouth. When moistened with a small quantity of water it
forms a tenacious, ductile, kneadable paste. When heated to
a red heat it shrinks considerably in bulk, and at last becomes so
hard as to strike fire with flint. After being ignited it is no
longer capable of being kneaded with water into a ductile mass.
Acids however dissolve this property by solution in an acid and pre-
cipitate. Alkalies dissolve it in the humid way, and form com-

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF ALUMINE.

EXPERIMENT I.

Alumine possesses a powerful attraction for lime.

THIS may be proved by agitating together fresh prepared lime water and alumine. On separating the water by filtration it will be found to be totally deprived of the lime it held in solution.

EXPERIMENT II.

Alumine is soluble in liquid alkalies.

If one part of alumine be boiled for some time, with six parts of potash, soda, &c. in a sufficient quantity of water, a perfect combination will take place, which may be decomposed again either wholly or in part by the addition of an acid.

EXPERIMENT III.

Alumine combines with silex in the humid way.

If we mingle together a concentrated solution of alumine and potash, and a like solution of silex, and suffer the mixture stand for a few hours, a precipitate takes place consisting of alumine and silex.

REMARK...This experiment proves that there exists a strong affinity between silex and alumine. Guyton de Morveau has been deceived in every instance of the affinities, which he attributes to the earths upon each other,* excepting in this case which has been observed before him by Chenevix.† He has attributed phenomena to substances which do not partake of it, but which resulted from the impurities of his re-agents,

EXPERIMENT IV.

Alumine, sulphur and charcoal form a compound which takes fire spontaneously in atmospheric air.

(Preparation of pyrophorus.)

In order to prepare pyrophorus, equal parts of powdered alum and brown sugar are melted over the fire, and are kept stirring, till reduced to dryness. The mixture is then to be finely powdered, and introduced into a common phial, coated with clay, to which a glass tube, open at each end, is luted, to allow the escape of the gases that are produced. The phial must then be set in the fire, surrounded by sand, in a crucible. Gas will issue from the open end of the tube, and may be inflamed by a lighted paper. When this ceases to escape, the crucible may be removed from the fire; and a little moist clay pressed down upon the open end of the tube, to prevent the access of air to the contents of the phial.

The pyrophorus thus formed is a black and very light powder, which instantly takes fire, when poured out of the bottle into the air; and inflames vividly in oxygen gas.

RATIONALE...The accension of pyrophorus is thus accounted for by Gren.‡ Part of the charcoal decomposes in a red heat part of the sulphuric acid of the sulphate of alumine, and becomes

* Ann. de Chem. XXXI. † Philosoph. Trans. May, 1802.

‡ Gren's Principles of Chemistry, vol. I. p. 256.

converted into carbonic acid gas, which escapes; the sulphuric acid is thus partly converted into sulphur, which sublimes and burns. During these changes, the potash, which is present in the alum of commerce, unites to part of the sulphur and forms with it a sulphuret of potash; and there remains the superfluous part of the coal that had been blended with the sulphate of alumine. The constituent parts of the pyrophorus are consequently exceedingly dry potash, sulphur, charcoal, and alumine. On exposure to air, the first rapidly attracts its moisture, and is heated with it. This heat is sufficient to inflame the sulphur, because sulphur is already, by its own nature, when combined with alkaline substances, by far more disposed to decompose oxygen gas. Lastly, this ignition of the sulphur in the pyrophorus is communicated to the coaly particles, that, at the beginning of its preparation, were mingled with the sulphate of alumine.

METHOD OF MAKING POTTERY.

Pottery or stone ware of all sorts, from the coarsest brown pitcher to the finest porcelain is made of alumine and silex. The use of the flint is to give strength to the ware, so that it may preserve its solidity during baking. In making the English stone ware, care is taken to employ only the fine parts of the alumine and chert, a species of flint. With this view the alumine is much beaten in water, by which the fine parts, being mixed with the fluid, are suspended, while the coarser sink to the bottom of the vessel. The thick liquid is further purified by passing it through hair and lawn sieves of different fineness; after this the liquid is mixed in various proportions for different wares, with another liquor of about the same density, and consisting of ground flints. The mixture is then dried in a kiln, and after being beaten to a proper consistence it becomes fit for being formed at the wheel, into dishes, plates, bowls, &c. When the ware has been exposed to heat for a certain time it is glazed, or is made to undergo a partial vitrification at the surface, without which it

would be pervious to fluids. Ordinary pottery is glazed with a semi-vitreous oxid of lead, or by throwing common salt over it in the furnace.

The yellow or queen's ware, is made of the same substances as the common flint ware, but in different proportions. The glazing is also different, it is made by mixing together in water to a consistence of cream, 112 parts of carbonate of lead, 24 parts of ground flint, and 6 of flint glass. The ware before it is glazed is baked in the fire, by which it acquires the property of strongly imbibing moisture; it is then dipped in this composition and quickly taken out. It is afterwards exposed a second time to the fire, by which means the glaze it has imbibed is melted, a thin glossy coat is formed upon its surface which is more or less yellow, according as a greater or less proportion of lead has been used. Porcelain, or china, is a semi-vitrified earthen ware of an intermediate nature, between common wares and glass. Chinese porcelain is said to be composed of two ingredients, one of which is a hard stone called *Petuntse*, which they carefully grind to a very fine powder; and the other, called by them *Kaolin*, is a white earthy substance, which they mix intimately with the ground stone. The former is of the siliceous, and the latter of the aluminous nature.

The manufacture of bricks is a coarser species of the same art,

GLUCINE.*

PART LX.

SECT. I.

NATURAL HISTORY OF GLUCINE.

FOR the discovery of this earth we are indebted to Vauquelin who found it in 1795, in the Aigue-marine or beryl, a transparent stone of a green colour, and in the Emerald of Peru. It exists combined with silex, argil, lime, and oxid of iron in the one; and with the same earths, with oxid of chrome, in the other. It has lately been discovered in the Gadolinite by Mr. Ekeberg.*

Its name is taken from the Greek word (*γλυκύς*) which signifies sweet or saccharine, because it gives that taste to the salts it forms.

PROPERTIES OF GLUCINE.

Glucine is white, light, and soft to the touch. It is insipid and adheres to the tongue; and is infusible by itself in the fire.

* *Journal des Mines*, An. X., No. 40.

METHOD OF ESTIMATING CARBONIC ACID.

Specific gravity = 1.387. It is soluble in alcohol and ether, and in all the acids except carbonic acid which it decomposes. It fuses with them, melting and slightly volatilizing. It is ~~moderately~~ soluble in sulphuric acid and in nitric acid with boric acid, and forms with it a transparent glass. It dissolves ~~one-fourth~~ of its weight of carbonic acid. It decomposes alumine. It is not precipitated by the salts of tartaric acid, nor by prussiate of potash, but by all the common acids. Solubility for the acids is ~~intermediate~~ ~~between~~ ~~acids~~ ~~and~~ ~~alkalis~~.

METHOD OF ESTIMATING CARBONIC ACID.

obtain glass

with

in

ZIRCON.

PART LXI.

SECT. I.

NATURAL HISTORY OF ZIRCON, OR JARGON.

THIS earth was discovered in the year 1793, by Klaproth Berlin, in the Zircon or Jargon, a gem first brought from island of Ceylon, but also found in France, Spain, and of parts of Europe. Its colour is either grey, greenish, yellow reddish-brown, or purple. It has little lustre, and is not opaque. It is likewise found in another gem called the hyacin. This stone is of a yellowish red colour mixed with brown. It possesses lustre and transparency.

PROPERTIES OF ZIRCON.

Zircon earth has a white colour, is exceedingly heavy, rough or harsh to the touch like silex. It has neither taste or odour, and is insoluble in water, but forms with it a kind of gel.

It melts with borax into a transparent colourless glass. It suffers in a charcoal crucible a pasty fusion by intense heat, and contracts in its dimensions, acquiring a grey colour and scintillating hardness. In this state it is very hard and insoluble in acids. Its specific gravity is 4.3. Neither air nor combustible bodies act upon it. It is soluble in water, but retains while drying in the air a large quantity of it, which gives it the semi-transparency and appearance of a yellow jelly, or gum-arabic; it exhibits the same vitreous fracture. It unites with all the acids and forms salts, differing from those of the other bases by being decomposable by alumine, glucine, the alcalies, and by mere heat. It fuses with alumine and silex. It is insoluble even by boiling in a solution of alcalies, neither can it be fused with them by means of heat; but it is soluble in alkaline carbonates.

By these properties this earth may be distinguished from every other. It is still of no use in the arts.

METHOD OF OBTAINING ZIRCON.

Reduce the mineral to powder, mix it with three times its weight of potash, and fuse it in a crucible. Wash the obtained mass in distilled water, till the whole of the potash be extracted; then dissolve the residuum as far as possible in diluted muriatic acid. Boil the solution to precipitate any silex it may contain, filter it, and gradually add solution of potash. The zircon will now become precipitated. Wash it repeatedly in distilled water and dry it.

SECT. II.

EXPERIMENTAL PROOFS
OR
THE PROPERTIES OF ZIRCON.

EXPERIMENT I.

Sulphuric acid and zircon unite readily.

INTRODUCE zircon, gradually, into diluted sulphuric acid until it dissolves no more when boiling hot. The salt which results from this combination is white, insoluble in water, and without any sensible taste. Heat decomposes it and leaves the zircon pure. It is not affected by acids, but alkalies and earths decompose it. Charcoal converts it, in a high temperature, into a sulphuret, which is soluble in water, and affords by evaporation crystals of hidro-sulphuret of zircon.

EXPERIMENT II.

Combination of nitric acid with zircon.

This combination may be effected in a similar manner to the last. It is impossible, however, to saturate the nitric acid with this earth, so as to destroy its acid properties, for the nitrate of zircon always changes the blue infusions of vegetables in the same manner as acids.

REMARK...Nitrate of zircon dissolves in a small quantity of water. To obtain it in a state of crystallization, it is necessary to evaporate it in a very gentle heat, or by simple exposure to the air.

The nitrate of zircon is decomposed,...1. by sulphuric acid, which forms with it a white precipitate, soluble in an excess of that acid; 2. by carbonate of ammonia, which produces in it a deposit, soluble in an excess of that salt; 3. by an infusion of galls in alcohol, a white precipitate is produced, soluble in an excess of the infusion. The greater part of the vegetable acids take zircon from the nitric, and form with it insoluble compounds.

EXPERIMENT III.

The muriatic acid unites readily with zircon, when in a state of extreme comminution, or when combined with carbonic acid.

This fact may be proved, by introducing zircon into muriatic acid in the usual manner, in either state.

REMARK...Muriate of zircon has no colour. Its taste is astringent. It is very soluble in alcohol, to the flame of which it does not communicate any particular colour. The muriatic acid is expelled by heat. This salt forms concretions in the mouth in consequence of being decomposed by the saliva. The solution of it affords, by a careful evaporation, small transparent needle-like crystals of a form difficult to be determined, which lose their transparency in the air, by giving out a portion of the water of crystallization.

Muriate of zircon is decomposed,...1. By sulphuric acid. A part of the sulphate of zircon which is formed, is precipitated in the form of heavy white flocks, while another portion is retained in solution by the muriatic acid. But if this acid be dissipated by heat, the remaining portion of the sulphate of zircon is gradually deposited, and if the evaporation of the liquor be stopped before that is reduced to dryness, it forms a kind of jelly, by

3. The gallic acid precipitates the muriate of *zircon* in the form of a white matter, (or in that of a greyish grain of iron). The liquor in which the gallate of zircon is formed preserves a greenish colour; and, though the salts of gallic acid do not occasion any more precipitation of ammonia separates a very copious floccy mass which has a purplish colour, similar to that of lees of wine.

These experiments prove, ... 1. That the gallic acid has a greater affinity with zircon than the muriatic acid; 2. That the gallate of zircon is soluble in muriatic acid, and that if it remained in solution in the liquor which was saturated with ammonia.

2. Carbonate of potash, saturated with carbonic acid, precipitates zircon from its solution in muriatic acid; if this solution be made with effervescence, the precipitate, when washed and dried in the air, retains a large portion of the muriatic acid, for this earth afterwards produces a lively effervescence when dissolved in acids.

3. A solution of sulphurated hydrogen gas in water, saturated with a solution of zircon (containing iron) disturbs the transparency of the solution, and gives to it a reddish colour; but it does not occasion a true precipitate. The hidro-sulphurated ammonia instantly precipitates this salt of a beautiful colour, which is blackish brown. This

The carbonate of ammonia produces at first a deposition of zircon, but fresh quantities of ammoniacal salt resolve the greater part of the precipitate. In this case a triple salt is formed, which may be decomposed by heat.

The prussiate of mercury produces in the solution of muriate of zircon, a very copious precipitate, soluble in muriatic acid.

The deposition cannot be owing to the combination of the mercury with the muriatic acid, for none of the salts into which the muriate of zircon enters form a precipitate with the prussiate of mercury. Were we even to suppose this case to be an exception, still the deposit would not be soluble in simple muriatic acid.

A plate of zinc, introduced into a solution of muriate of zircon, occasions a slight effervescence, owing to the disengagement of hydrogen gas. The liquor becomes milky, and at the end of some days assumes the form of a white semi-transparent mass.

Pure alumine decomposes the muriate of zircon, by the assistance of a slight heat. The alumine is dissolved, the liquor becomes milky, and assumes a gelatinous form in cooling. When the muriate of zircon contains iron, it remains in solution with the alumine, so that the zircon which is precipitated does not contain any sensible quantity of that metal....See Klaproth's *Chemie*, *Vauquelin, Ann. de Chem.*: Tom. xxii. p. 179.

AGUSTINE.

PART LXII.

NATURAL HISTORY OF AGUSTINE.

THIS is a new earth discovered in the Saxon Beryl, or Beryl of Georgien Stadt, a stone greatly resembling the Beryl of Siberia, by professor Tromsdorff of Erfurth in Germany,* to which he has given the name of agustine on account of the property of forming salts which are nearly destitute of taste.

PROPERTIES OF AGUSTINE.

Agustine is white and insipid; when moistened with water it is somewhat ductile, but is not soluble in that fluid. Exposed to a violent heat, it becomes extremely hard, but acquires no taste. It combines with acids, forming salts, which have little or no taste. It does not combine either in the humid or dry way with alcalies, or with their carbonates. It retains carbonic acid but feebly. It dissolves in acids equally well after having been hardened, by exposure to heat, as when newly precipitated. With sulphuric acid it forms a salt which is insipid, and scarcely soluble, but an excess of acid renders it soluble, and capable of crystallizing in stars. With an excess of phosphoric acid it forms a very soluble salt. With nitrous acid it forms a salt scarcely soluble.

* Ann. de Chemie, xxxiv. 133.

WITNESS.

PART II.

SCIENTIFIC APPENDIX AND INDEX.

THE discovery of this new acid was first made by Dr. V. V. Verity, from samples which he had found, and subsequently confirmed by Wenzelius and Klaproth.

PROPERTIES OF VITRIOL.

Vitriol is the heaviest of the acids. Its specific gravity is 1.82, resembles glycine in several of its properties. It is a smooth and pale. It is infusible alone, but fuses with a proportionate quantity of soda. It combines with the acids, and is precipitated from its solutions by ammonia and prussiate of potash. It is also precipitated by tannin. The precipitate is not soluble in ammonia. As some of its salts are coloured, and its weight nearly approaches to that of metals, it is considered as the link which connects

MAGNESIA,

PART LXIV.

SECT. I.

NATURAL HISTORY OF MAGNESIA

THIS earth is not found pure in nature, but is obtained by art from some of its combinations. It gives a peculiar character to the substances of which it forms a part. The stones which contain magnesia in considerable quantity, have generally a smooth and unctuous feel, a greenish cast, a fibrous or striated texture, and a silky lustre. Among them we may mention *talc*, *steatite*, *serpentine*, *chlorite*, *asbestos*, *actynolite*, *jade* or *nephritic stone*, *baikalite*, *boracite*, &c. It is likewise found neutralized with various acids. It has been discovered by Vauquelin, in several sea-plants.*

PROPERTIES OF MAGNESIA.

Pure magnesia does not form with water an adhesive ductile mass. It is in the form of a very white spongy powder, soft

* Ann. de Chemic. xviii, 78.

to the touch, and perfectly tasteless. It is very slightly soluble in water. It absorbs carbonic acid gradually from the atmosphere. It changes very delicate blue vegetable colours to green. Its attraction to the acids is weaker than those of the alkalies. Its salts are partially decomposed by ammonia, one part of the magnesia being precipitated, and the other forming a triple compound. Its specific gravity is about 2.3. It is infusible even by the most intense heat; but when mixed with some of the other earths it becomes fusible. It combines with sulphur. It does not unite to phosphorus or carbon. It is not dissolved by alkalies in the humid way. When heated strongly it becomes phosphorescent. With the dense acids it becomes ignited. With all the acids it forms salts of a bitter taste, mostly very soluble.

METHOD OF OBTAINING MAGNESIA.

The usual method of procuring magnesia, is to precipitate it from sulphate of magnesia by means of an alcali.

To effect this dissolve any quantity of sulphate of magnesia in a large quantity of distilled water and add to it gradually a solution of perfectly pure carbonate of potash, or soda, till no more precipitate ensues. Then collect the precipitate on a cloth and boil it repeatedly in a large quantity of distilled water, till this fluid passes perfectly tasteless. It is then to be dried, and exposed in a crucible to a red heat, till a sample of it, when cold, does not occasion the least effervescence with acids.

RATIONALE... In this process a double decomposition takes place, the sulphuric acid of the sulphate of magnesia combines with the alcali, and forms sulphate of potash; and the carbonic acid of the alcali joins to the disengaged magnesia, and forms carbonate of magnesia; the latter is precipitated, and the sulphate of potash remains in solution. On exposing the carbonate of magnesia to heat, the acid is expelled and the magnesia is left behind in a pure state.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF MAGNESIA.

EXPERIMENT I.

Magnesia converts vegetable blues into green.

MIX one part of magnesia with six of water, shake the mixture for a few minutes, and then separate the water by filtration. If this water be mingled with a pale blue mixture of cabbage, the fluid will instantly become green.

Magnesia resembles in this respect the alcalies, and hence it has been classed by some chemists amongst these bodies. It seems to form the link which unites the earths with the alcalies.

EXPERIMENT II.

Magnesia does not form an adhesive mass with water.

If magnesia and water be mixed together, no adhesive or ductile mass can be obtained. It is capable however of retaining this fluid very obstinately; for if 100 parts of magnesia are thrown into water and then dried, its weight is increased to about 118.

EXPERIMENT III.

Magnesia attracts carbonic acid from the air.

If any quantity of magnesia be exposed to the air for some time it soon attracts carbonic acid, which may be proved by pouring on it an acid, which causes a slight effervescence.

EXPERIMENT IV.

Carbonic acid has a stronger affinity for lime than for magnesia.

This may be evinced by digesting carbonate of magnesia in fresh prepared lime-water. The lime will attract the carbonic acid from the magnesia and be rendered insoluble. Hence the taste of lime-water is totally destroyed by carbonate of magnesia.

EXPERIMENT V.

Ignition of magnesia by the diffusion of sulphuric or nitric acid.

This experiment has been noticed already, vol. I. page 134.

EXPERIMENT VI.

Magnesia combines with sulphur.

See vol. I. page 152.

The other properties of this earth require no experimental investigation.

ALCALIES.

ALCALIES.

PART LXV.

WE consider these substances (one of them excepted) as simple bodies, though several chemists have asserted that they are compound; others have even endeavoured to prove this by experiment, but none of their proofs are yet satisfactory.

Were we permitted to judge from analogy we should be inclined to suppose that all alcalies possess one common base, for they have a great number of properties which are common to them all. We have indeed seen that one (ammonia) has been decomposed; we have proved that nitrogen enters into its composition, (see vol. I. p. 314, &c.) but no conclusion can be drawn from this. We are therefore forced to consider the rest of them as simple bodies, till future discoveries remove the veil which at present obstructs our view.

ENUMERATION OF ALCALIES.

BARYTES,
POTASH,
SODA,
STRONTIA,
LIME,
AMMONIA.

GENERAL PHYSICAL PROPERTIES OF ALCALIES.

All alcalies are incombustible, and soluble in water; they possess an acrid, urinous taste. When mixed with siliceous substances and exposed to an intense heat, they form a more or less perfect glass. They unite with another class of bodies called acids, and form new compounds, in which both the acid and alkaline properties are more or less lost. They render oils miscible with water. They change various blue vegetable pigments to green; red to violet or blue; and yellow to brown. Blue pigments that have been turned red with acids are again restored by alcalies to their primitive colours. They emit light on the affusion of the dense acids when freed from water. They attract water and carbonic acid from the atmosphere. They unite to sulphur by fusion and by means of water. They exert a great solvent power on the cellular membrane and animal fibre; they also corrode woollen cloth, and if sufficiently concentrated convert it into a sort of jelly.

THE PROOFS OF THE PROPERTIES OF BARYTES.

SECT II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF BARYTES.

EXPERIMENT I.

Barytes changes blue vegetable colours green.

fall into a wine glass full of distilled water rendered blue by the admixture of tincture of cab-

barytes. The blue colour of the fluid will

disappear and be replaced into a lively green.

EXPERIMENT II.

Barytes changes red vegetable colours violet.

in a similar manner to water rendered red by

the admixture of tincture of red ochre, a small quantity of barytes be added, the

red colour will be changed into a violet.

EXPERIMENT III.

Barytes changes yellow vegetable colour brown.

paper, stained yellow with an infusion of turmeric, be dipped into a solution of barytes, it will soon lose its yellow colour become brown.

EXPERIMENT IV.

Barytes renders oils miscible with water.

One part of oil of olives be put into a phial and agitated with three of a concentrated solution of barytes, a viscous mass will be obtained diffusible in water.

EXPERIMENT V.

Barytes gives out heat on being united to water.

Fresh-prepared barytes be sprinkled with water it gradually swells up and bursts, it solidifies the water, and becomes consolidated. If a little more water be gradually added it hardens still more, and, if left for some time undisturbed, becomes so hard as to form a kind of cement: a still larger addition of this water changes it into a white powder exceedingly voluminous, soluble in water.

EXPERIMENT VI.

Barytes forms glass with silex.

Take a few grains of silex and double the quantity of barytes on a bed of charcoal, urge it well with heat by means of the blow-pipe.

The mixture will melt and a globule of glass will be observed.

SECT II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF BARYTES.

EXPERIMENT I.

Barytes changes blue vegetable colours green.

LET fall into a wine glass full of distilled water, rendered slightly blue by the admixture of tincture of cabbage, a few grains of barytes. The blue colour of the fluid will instantly be converted into a lively green.

EXPERIMENT II.

Barytes changes red vegetable colours violet.

If in a similar manner to water rendered red by tincture of brazil wood, a small quantity of barytes be added, the red colour will be changed into a violet.

EXPERIMENT III.

Barytes changes yellow vegetable colours brown.

Let paper, stained yellow with an infusion of turmeric, be dipped into a solution of barytes, it will soon lose its yellow colour and become brown.

EXPERIMENT IV.

Barytes renders oils miscible with water.

If one part of oil of olives be put into a phial and agitated together with three of a concentrated solution of barytes, a saponaceous mass will be obtained diffusible in water.

EXPERIMENT V.

Barytes gives out heat on being united to water.

If fresh-prepared barytes be sprinkled with water it gradually swells up and bursts, it solidifies the water, and becomes considerably heated. If a little more water be gradually added it hardens with it; and, if left for some time undisturbed, becomes so hard that it forms a kind of cement: a still larger addition of this fluid changes it into a white powder exceedingly voluminous, and soluble in water.

EXPERIMENT VI.

Barytes forms glass with silex.

Put a few grains of silex and double the quantity of barytes on a piece of charcoal, urge it well with heat by means of the blow-pipe. The mixture will melt and a globule of glass will be obtained.

POTASH.

PART LXVII.

SECT. I.

NATURAL HISTORY OF POTASH.

IF wood or vegetables be burnt in the open air, and the ashes repeatedly washed with water till it passes tasteless, and if the liquid be evaporated to dryness, the substance which remains is called *potash*; far however from being in a state of purity. In this state it occurs in commerce.

It is seldom found in an uncombined state, except in wells in towns, as at Douay, &c. It is said to exist in the aluminous ore of La Tolfa. In combination with the sulphuric, nitric, and muriatic acids, it is found in Spain and in the East Indies.

Potash was formerly denominated the vegetable alkali, but improperly, because it is met with abundantly in mineral bodies, more especially in volcanic products. Dr. Kennedy has lately discovered it in the pumice stone. Vauquelin has found it in the Zeolite from the Ferro islands. Klaproth has likewise discovered it in the *Leucite*, an earth of the siliceous genus.

Vegetable physiologists are not agreed whether potash be derived from the soil in which vegetables grow; whether it exists uncombined with any acid in plants; whether it be a product of vegetation; or whether it be generated during the process of burning.

Potash was for a long time unknown in its pure state, because it was difficult to obtain it. We shall examine its properties in that state, and then point out the methods of obtaining it.

PROPERTIES OF POTASH.

Potash, in a crystallized form, consists of soft quadrangular compressed prisms, which are extremely caustic, and deliquescent. It dissolves all soft animal matters when brought into contact with it. It liquefies by a gentle heat, and rises in fumes at high temperatures. It does not unite in a direct manner with phosphorus. It easily combines with sulphur and metallic oxids. It dissolves alumine in the humid way, and even a small quantity of silex; but it does not act on glucine or zircon, nor on magnesia or lime. It contracts no union with barytes. It absorbs water and carbonic acid rapidly. It fuses into glass with silex by the aid of fire. It forms salts which in general do not yield their acid unless to barytes. It changes blue vegetable colours green, and possesses all the general properties of alcalies.

METHODS OF OBTAINING POTASH.

It has long been a desideratum with chemists to possess a method of preparing potash in a state of absolute purity; the strong tendency which it has to combination renders this extremely difficult. The following are the methods now made use of.

1. Bouillon la Grange'sapp aratus* consists of several boxes of common deal. At the bottom put river-sand, which must be well washed, and over it add another stratum, but of a finer kind, and cover the whole with a cloth, besprinkled with wood-ashes. In the bottom of each box a hole is made, into which is

fitted a glass tube, for the purpose of affording a passage in the liquor as it filters through the sand.

Having arranged the apparatus in this manner, take equal parts of quick-lime and potash of commerce, if the lime is very caustic; but in the contrary case, it requires twenty parts of lime to fifteen of potash: put water into an iron kettle, bring it nearly to a state of ebullition, and then add lime, which by its slaking will bring the water to that state completely. When it is slaked mix the potash, and form of the whole a thick liquid which must be suffered to cool a little. Then pour the mixture into the boxes, and immediately throw water over it; but to prevent the water from making holes, when added, place over it a small board, which will rise with the water.

Care must be taken to place earthen pans, or other vessels, receive the liquor which runs through the tubes; and, that they may not absorb carbonic acid from the atmosphere, the vessels must be closed with care, in such a manner as to exclude the external air. It will be necessary also to keep water always over the mixture, which must be collected till it passes taste from the tubes.

The liquors obtained are nearly of the same degree of strength till towards the end of the process; when they grow weak suddenly.

To evaporate the water, use should be made of cast-iron pans, beginning with the last portions, which are a little weaker; to prevent the necessity of keeping the strongest a long time in contact with the air when boiling, a strong ebullition is required. When the fluid is concentrated to a certain degree, any sulphate of potash that may be present will crystallize, and be precipitated.

To obtain dry potash, pour the concentrated liquor into a small basin, and proceed with the evaporation, till a little of it poured on an iron plate, or a marble slab, becomes solid.

Then put the concrete potash into a jar, and pour over it a strong alcohol; the potash alone dissolves in it; the sulphate

trate of potash, with the portions of earth and even of carbonic acid, which it obstinately retains, or which it may have acquired from the air during the evaporation, remain at the bottom of the solution. Afterwards decant the pure liquor, and distil it in a retort till it becomes colourless. It must then be evaporated in a silver bason. On cooling, it crystallizes in white prisms, which are sometimes three-tenths of an inch in length: instead of suffering it to crystallize it may be evaporated to dryness.

2. Lowitz has given another method.* According to this eminent the whole of the operation for obtaining potash of the purest purity, and without the least colour, consists in this: A lixivium of potash, freed from carbonic acid in the usual manner, evaporated to a thick pellicle. After the cooling, the foreign salt which has crystallized is to be separated, and the evaporation of the lixivium continued in an iron pot. During this second evaporation the pellicle of foreign salts, particularly of carbonate of potash, which continues to be formed, must be carefully taken off with an iron skimmer. When no more pellicle is formed, the matter ceases to boil up, it is removed from the fire and suffered to cool, continually stirred with an iron spatula. It is then to be dissolved in double the quantity of cold water, and the solution filtered, and evaporated in a glass retort, till it begins to deposit regular crystals. If the mass should consolidate even so early by cooling, a small quantity of water is to be added, and must be heated again to render it fluid. After the formation of a sufficient quantity of regular crystals, the fluid, which is very brown, is to be decanted, and the salt, after being suffered to drain, must be re-dissolved in the same quantity of water. The decanted fluid must be kept in a well-closed bottle, and suffered to become clear by subsiding during several days. It must then be decanted for a second evaporation and crystallization. The process must be repeated as long as the crystals af-

ford, with the least possible quantity of water, solutions perfectly limpid. These solutions are to be preserved in well-closed bottles, to defend them from the access of air.

The greatest difficulty of this process arises from the facility with which the fluid assumes a solid form. To obviate this inconvenience, a small portion of it may be concentrated to the point at which it becomes converted into a solid mass by cooling. The saturation of a lixivium considerably evaporated may be ascertained by throwing small pieces of this mass into it during its cooling. When these are no longer dissolved, it is a proof that it is at the required point.

With regard to the foreign salts which are mixed with the potash, the greatest portion separates by crystallization after the first evaporation. The rest is separated during the second concentration by the continual skimming of the pellicle. The little which may remain with the potash must precipitate for want of water of solution, in a lixivium, wherein the alcali itself is no longer dissolved but by its own water of crystallization.

REMARKS.

The property of alcalies to dissolve in highly rectified alcohol, with the exclusion of every foreign salt, would afford an excellent means of obtaining potash very pure, if their mutual action did not afford a new source of impurity. For when an alcali absolutely pure and crystallized is dissolved in spirit of wine, even without heat, the fluid assumes a very brown colour, which becomes still deeper after being decanted from the saline mass.

The crystallization of potash is very different, accordingly as the crystals are formed with cold or heat. In the first case, the crystals obtained are octahedra in groups, which contain 0.43 water of crystallization, and excite by their solution in water, even in the summer, a degree of cold very near the point of aqueous congelation. In the second case, very thin crystalline transparent blades of extraordinary magnitude are formed, which

by an assemblage of lines, crossing each other in infinite directions, present an aggregate of cells or cavities, most commonly so perfectly closed that the vessel may be inverted without the escape of the smallest drop of the lixivium, though sometimes included to the amount of an ounce or two. For this reason, it is necessary to break this fine crystallization, that the fluid may run off. The crystals present in their regular formation rectangular tetragonal blades, which as they contain little water of crystallization, produce a considerable degree of heat when dissolved in water.

By exposing such alkaline crystals to a red heat in a silver crucible, they become fused; and, after cooling, afford a mass as white as snow, extremely caustic and deliquescent.

As the crystals and the lixivium, during the length of time required to drain the salt, may frequently become charged with a portion of carbonic acid, it is advisable, in order to avoid this inconvenience as much as possible, that the lixivium, as soon as it is brought to the requisite point of concentration, should be poured into a narrow-necked bottle, and well closed therein to crystallize. After the crystals are formed, the bottle is to be reversed without opening, and kept at a temperature rather warm until the crystals are well dried. During the winter, the liquor, after the first crystallization, continues to crystallize without being submitted to a new evaporation, provided only that it be exposed to a temperature somewhat colder than that wherein the first crystals were formed.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF POTASH.

EXPERIMENT I.

Potash rapidly absorbs water and carbonic acid from the atmosphere.

If potash be exposed to the air in an open vessel, it soon attracts humidity and carbonic acid, augments in weight, becomes liquid, and gradually assumes the state of liquid carbonate of potash. To preserve it in a state of purity it must therefore be kept in bottles well stopped and entirely filled with it.

REMARK... When dry, or fused potash is dissolved in water, it first absorbs a certain quantity which it solidifies, caloric is evolved, and then the potash dissolves in the excess of water which is added. The absorption of water by potash is therefore really a combination in consequence of the affinity it exercises, and is very different from the simple extension of a salt in a liquid by solution; this is the reason why sensible caloric is evolved from potash and water, and the rest of the alkalies.

This effect does not take place but when the alkalies are in a dry state, or freed from the water of crystallization; for if they are in a crystallized state when added to the water, *cold* is produced, because there is no water to be solidified. A solid then passes into a state of liquidity. This we have considered already more circumstantially under the article Heat.

EXPERIMENT II.

Potash combines with silex in the dry way.

If potash and silex are fused together, a combination is obtained known under the name of glass. This product differs according to the quantities of silex and potash of which it is composed.

If three or four parts of potash be fused with one of silex, the result will be a soft brittle kind of glass, which is soluble in water. This solution is called liquid siliceous potash, or improperly liquor of flints.

To prepare this liquid, take one part of silex, reduced to a fine powder (or pure sand) and three or four parts of potash; put these two substances into a crucible which must be only half filled, and place the crucible in the fire. As soon as the matter enters into fusion, it puffs up considerably, and continues to swell till the alcali has dissolved the silex. The crucible is to be kept uncovered as long as the effervescence lasts, but when it is over, cover the crucible and augment the heat till the whole fuses quietly. The contents are then poured out on a dry iron plate or stone, the matter as it cools becomes hard and assumes the appearance of glass. This matter, when pulverized and dissolved, by pouring water over it, forms liquid siliceous potash. It is decomposable by acids, and pure siliceous earth may be obtained from it in that way as mentioned before.

EXPERIMENT III.

Potash acts very powerfully upon animal substances.

Immerse a slip of woollen cloth, or a piece of muscular flesh into a concentrated solution of potash, the animal substance will soon become destroyed, and form with the potash a homogeneous compound.

EXPERIMENT IV.

Potash has a strong affinity for sulphur.

When equal parts of potash and sulphur are triturated together in a glass mortar, the sulphur soon acquires a green colour, the mass becomes pasty, its temperature is raised, and a sulphuret of potash is obtained.

EXPERIMENT V.

Potash and snow produce a great degree of cold.

When four parts of crystallized potash reduced to powder, and three of uncompressed snow, are hastily mingled together, the mixture becomes fluid, and an intense degree of cold is produced, which under proper circumstances is — 51° Fahr.

EXPERIMENT VI.

Potash and dense acids produce a great degree of heat.

If equal weights of potash freed from its water of crystallization by fusion, and dense sulphuric acid are mingled together, a great degree of heat will be instantly produced, and a flash of light will be seen to pervade the mixture if the experiment be made in the dark.

SODA.

PART LXVIII.

SECT. I.

NATURAL HISTORY OF SODA.

THE name of soda is given to the next alkali, which greatly resembles potash. Hitherto we are not better acquainted with the nature of soda than with that of potash, being equally uncertain whether it previously existed ready formed in the vegetable; or if it be a combination of certain radicals effected during the process for obtaining it.

Soda frequently occurs in the mineral kingdom, united with sulphuric, muriatic, and boracic acids; it is also found in large quantities in Egypt, combined with carbonic acid. It appears to be deposited in large impure masses, under the surface of the earth, in various countries, from which it is extracted by running water. Thus it is found after the spontaneous evaporation of the water, mixed with sand in the bottom of lakes in Hungary; in the neighbourhood of Bilin in Bohemia; and in Switzerland. It occurs also in China, and near Tripoli in Syria, Egypt, Persia, and India. It frequently oozes out of walls and crystallizes on their surface.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF STRONTIA

EXPERIMENT I.

Strontia tinges the flame of burning bodies carmine-red.

THIS may be shown by dissolving either strontia, or nitrate or muriate of strontia in ardent spirit and setting fire to the solution, which will burn with a carmine-red flame.

REARK...The experiment is best performed by moistening the strontia with ardent spirit in a silver spoon, setting fire to the mixture, and holding it while burning over the flame of a candle in order to cause a quick and rapid combustion.

REARK...It is curious that moisture is absolutely necessary, for if the alcali be totally deprived of water by heat it does not produce this effect.

A beautiful red fire may also be produced by mixing one part of nitrate of strontia with two or three parts of charcoal powder and setting fire to the mixture with a red hot coal or a poker.

EXPERIMENT II.

Strontia combines with sulphur.

(Sulphuret of Strontia.)

If equal parts of strontia and sulphur are mingled together and exposed to a red heat, the substances unite and form a sulphuret of strontia of a yellowish brown colour.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF SODA.

EXPERIMENT I.

Method of distinguishing soda from potash.

LET fall into a solution of the alcali to be investigated a few grains of oxalic acid ; for this acid forms with potash oxalate of potash, which is very soluble, and on the contrary with soda it produces oxalate of soda, which is of a very difficult solubility.

EXPERIMENT II.

Formation of soap.

The combination of soda or potash, with oils, or fat in general, forms the compound called *soap*. The union of oil, &c. with potash, affords those called *soft soap* ; the combination of soda with the same substances affords those called *hard soap*. It is to be an established truth that potash combined with any fat can only afford a soap, to which no cooling can give

LIME.

PART LXX.

SECT. I.

NATURAL HISTORY OF LIME.

THIS substance we have transferred from the class of earth, and placed it among the alkalies, for it possesses all the characteristic properties of these bodies in a striking manner, its sparing solubility in water only excepted.

Lime is found in great abundance in nature, though never pure, or in an uncombined state. It is always united to an acid, and very frequently to the carbonic acid, as in chalk, common lime-stone, marble, calcareous spar, &c. It is contained in the waters of the ocean; it is found in vegetables; and is the basis of the bones, shells, and other hard parts of animals. Its combination with sulphuric acid is known by the name of sulphate of lime (*gypsum*, or plaster of Paris). Combined with fluoric acid it constitutes fluoate of lime, or Derbyshire spar.

Mottled soap is made in a similar manner as the last, the mottled appearance is given towards the end of the operation of boiling, by dispersing the ley through the soap, or by adding to it a quantity of a solution of sulphate of iron, which by its decomposition, deposits its oxid through the soap, and gives it an appearance of blue marble. In some manufactures the black oxid of manganese is made use of for the same purpose.

Yellow soap is made with tallow and resin; and these are reckoned good, if 10 cwt. of tallow, and 3½ cwt. of resin with the proper quantity of soda afford a ton of soap.*

Soap of wool may be made by boiling shreds of woollen cloth of any kind, with ley, till the whole has acquired a certain consistence. This kind of soap has been made and applied with success,† in several manufactures in France.

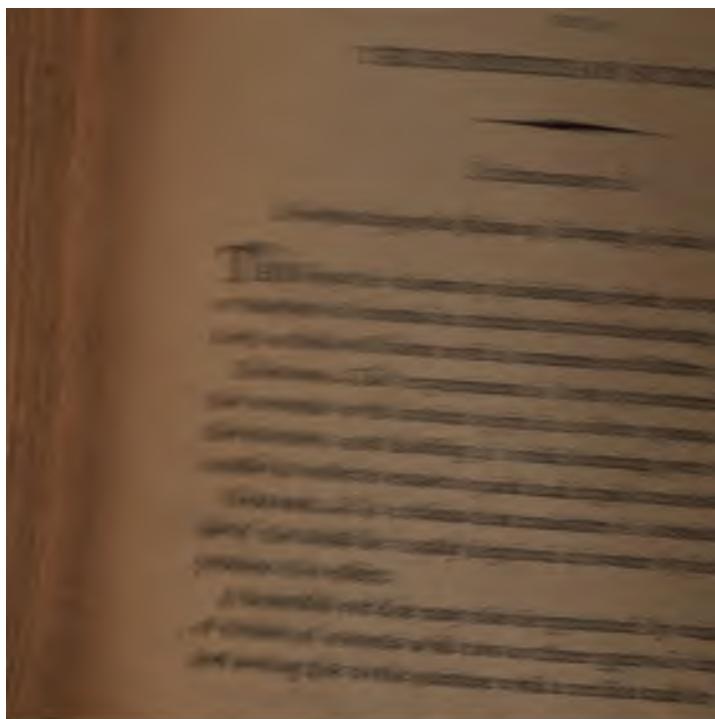
An ammoniacal soap may be produced, by pouring a concentrated solution of muriate of ammonia into a solution of common soap.

A soap of lime, barytes, and strontia, may be formed, by pouring solutions of these alkalies into that of common soap. These, together with the following terrene soaps, are insoluble, and possess no detergent properties.

Amongst the earthy soaps those of magnesia and alumine are the principal. Soap of magnesia is produced by mingling a solution of common soap with a solution of sulphate of magnesia. Soap of alumine is obtained by adding to a solution of soap a solution of alum of commerce.

* Nicholson's Journal, 4to edition, 1779, No. xxviii, p. 208.

† Ann. de Chimie, xxi, 27.



SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF LIME.

EXPERIMENT I.

Lime condenses water rapidly, with an increase of temperature.

THIS may be shown by sprinkling a little water on some fresh burnt lime. The above mentioned phenomena will take place, and the lime will fall into powder. The degree of heat produced, if a large piece of lime be slaked, is even sufficient to set fire to a brimstone match, if the latter be introduced into the crack of it. For similar reasons vessels loaded with lime have been set on fire.

EXPERIMENT II.

Lime has a strong attraction for carbonic acid.

If we bring a jar filled with carbonic acid gas in contact with lime-water, and agitate the latter, a rapid diminution will ensue, and the lime-water become milky. It may also be shown by letting a current of carbonic acid gas pass into lime-water.

FORMATION OF ACIDS.

ACIDS.

PART LXXIII.

FORMATION OF ACIDS.



ACCORDING to the theory of Lavoisier all acids consist of a certain base united to oxygen, which is considered to be the cause of acidity. We are acquainted with the bases of the sulphuric, nitric, phosphoric, arsenic, &c. acids: we know that hydrogen, carbon, and oxygen, form the bases of the citric, muriatic, oxalic, acetic, gallic, and all the rest of the acids called *vegetable*; and that the same substances, in combination with nitrogen, constitute those called *animal* acids, such as prussic, &c. But we are totally unacquainted with the radicals of the muriatic, boracic, and fluoric acids, they must therefore be analogically considered as simple bodies in the present state of our knowledge.

fore proves that carbonate of lime is not dissolved in water but by an excess of carbonic acid.

EXPERIMENT IV.

Lime absorbs carbonic acid and water from the atmosphere.

Lime-water remains unchanged in well closed vessels; but when exposed to the open air, it becomes covered with a thin pellicle, which, on becoming thicker, breaks and falls to the bottom, making room for another new crust, till at last all the lime is separated.

RATIONALE.—The cause of the alterations which the lime-water undergoes when exposed to the air, originates from the carbonic acid of the atmosphere, being powerfully attracted by the lime dissolved in the water, which thus becomes converted into an insoluble carbonate of lime.

The same changes take place with lime itself when in contact with common air: it first attracts moisture and then carbonic acid; and being thereby gradually slaked, it swells up, splits, falls to pieces, and loses its sharp taste. Its weight is increased, and it becomes effervescent. It sensibly returns to the state of carbonate of lime. The greater the humidity of the air, the speedier these phenomena take place, and are the more striking. During this gradual slaking, heat is perceptible, by the absorbed water losing its caloric. It feels therefore warm, and a thermometer immersed in it, rises considerably above the temperature of the surrounding medium.

EXPERIMENT V.

Lime is soluble in water, it tinges blue vegetable colours green.

When more water is added to lime than is necessary to slake it, it becomes at last dissolved. About 300 parts of

Class I....ACIDS WHOSE BASES ARE UNKNOWN, OR UNDECOMPOSABLE ACIDS.

MURIATIC ACID.

PART LXXIV.

MURIATIC acid exists in the gaseous state, and forms muriatic acid gas, which has been considered already, vol. I. p. 327. The basis of this acid is unknown.

PROPERTIES OF MURIATIC ACID.

Liquid muriatic acid, or water impregnated with muriatic acid gas, is a colourless, very odorous, and pungent fluid. It emits copious white fumes in contact with moist atmospheric air, these fumes are muriatic acid gas that escapes from it, and condense again by combining with the humidity of the air. If a wide-mouthed bottle containing strong muriatic acid be opened, and the hand brought near its orifice, a sensible warmth is perceived, which arises from the combination of the acid gas with the water of the atmosphere. Liquid muriatic acid is unalterable by

SECT. II.

RE-COMPOSITION OF WATER.

IT is, however, not sufficient to decompose water into its constituent principles, oxygen and hydrogen, to produce compleat conviction; we must re-compose it with the radicals which resulted from its decomposition: happily modern chemistry has enabled us to accomplish this.

It has been proved already, vol. I. p. 204, that oxygen and hydrogen gases, when fired in proper proportions, produce a quantity of water, equal in weight to the two gases employed; it is, therefore, obvious that, by thus exploding repeatedly portions of a mixture of these gases, a considerable quantity of water will at last be produced. This being established, it would be superfluous to dwell upon it further.

To perform the combustion of oxygen and hydrogen gases, for the production of water, conveniently, some particular kinds of apparatus have been invented. A simple contrivance, for showing the formation of it, we have noticed already, vol. I. p. 206: but the cheapest, most convenient, and most simple apparatus for that purpose has been invented by Mr. Cuthbertson, of which a description and drawing has been given in Nicholson's Journal, (4to edit.) vol. i. p. 235.

PROPERTIES OF MURIATES.

These salts yield white vapours (muriatic acid gas) by the effusion of sulphuric acid, and yellowish-green vapours (oxygenated muriatic acid gas,) by nitric acid; both attended with considerable effervescence. They are decomposed by solution of silver, and are volatile at high temperatures without decomposition.

METHODS OF OBTAINING MURIATES.

Muriate of potash, soda, ammonia, barytes, strontia, lime, magnesia, &c. may be obtained by dissolving the carbonates of these substances in muriatic acid, to perfect saturation, evaporating the solution, and suffering it to crystallize. Muriate of iron may be produced by dissolving iron filings in muriatic acid to saturation, evaporating the solution and crystallizing it. Muriate of tin, zinc, arsenic, and nickel, may be obtained in a similar manner. Muriate of lead is best prepared by pouring muriatic acid into a solution of nitrate of lead, the muriate of lead precipitates instantly. Muriate of gold is obtained by dissolving gold in nitro-muriatic acid. Muriate of silver is formed by pouring muriatic acid into a solution of nitrate of silver. Muriate of copper is produced, according to Chenevix, by mixing 54.5 parts of black oxid of copper, and 50 parts of copper obtained by precipitating that metal from its solution, by a plate of iron, and putting this mixture with muriatic acid into a well stopped phial; the solution will then contain muriate of copper. Muriate of mercury has been noticed already. Muriate of bismuth is obtained by dissolving this metal in nitro-muriatic acid. Muriate of antimony is formed in a similar manner.

BORACIC ACID.

PART LXXV.

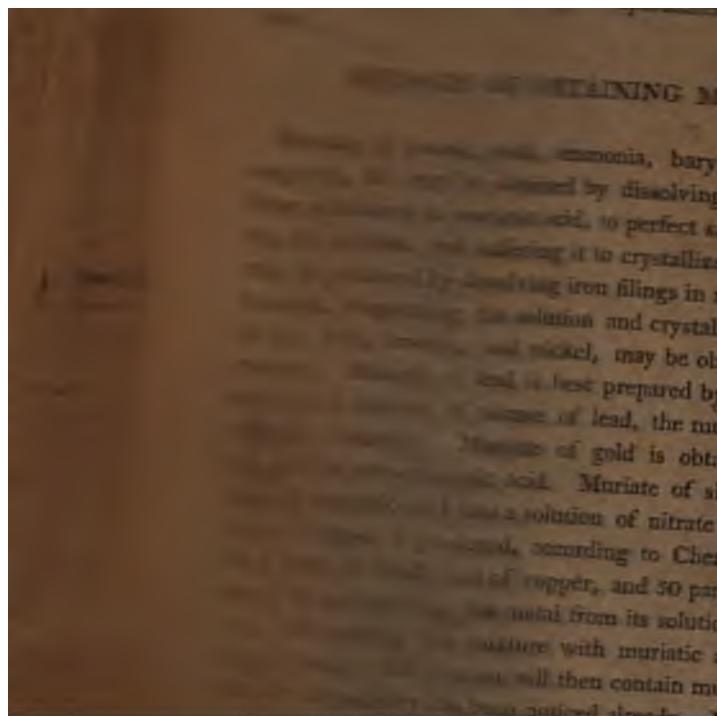
THE composition of this acid is also unknown. It exists united to soda in the salt called borax, or sur-saturated borate of soda. United to lime and magnesia, it forms the mineral called borate of lime.

PROPERTIES OF BORACIC ACID.

Boracic acid appears in brilliant, glittering, white, hexahedral scales, soft and unctuous to the touch. Its taste is bitterish, with a slight degree of acidity. It is soluble in alcohol which it causes to burn, when set on fire, with a green flame surrounded with a white one. It is of difficult solubility in cold water, but is easily dissolved in boiling water. When heated strongly it fuses into glass. If heated with water it is carried up by the aqueous vapour. It has no action on combustible bodies.

METHODS OF OBTAINING BORACIC ACID.

1. Dissolve any quantity of sur-saturated borate of soda in boiling water, and add to this solution sulphuric acid, by a little at a time, till the solution be rather more than saturated. Then



FLUORIC ACID.

PART LXXVI.

THIS is another acid of which the composition is unknown. It exists in a gazeous state and forms fluoric acid gas, (see Vol. I. page 343.) United to water it constitutes liquid fluoric acid.

PROPERTIES OF FLUORIC ACID.

The distinguishing property of fluoric acid is, its power of dissolving and volatilizing silex. Its odour resembles muriatic acid. On being exposed to a moist atmospheric air, it emits white fumes. Its action upon all the inflammable substances is very feeble; it does not afford oxygen to them. It has no action upon most of the metals, but it dissolves many of their oxids.

METHOD OF OBTAINING FLUORIC ACID.

Put one part of finely pulverized fluate of lime into a leaden or tin retort, and pour upon it two parts and a half of sulphuric acid. Lute the retort to a receiver of the same metal, contain-

Class II....ACIDS COMPOSED OF TWO BASES.

OXIGENATED MURIATIC ACID.

PART LXXVII.

THE name of oxygenated muriatic acid is given to the compound formed by the muriatic acid with oxygen. By this combination, however, the acid properties of the muriatic acid are not increased, as is the case with the other acids, but on the contrary, diminished.

Oxygenated muriatic acid exists in the state of gas, and as such has been considered, vol. I. p. 333. When absorbed by water it forms liquid oxygenated muriatic acid.

PROPERTIES OF OXIGENATED MURIATIC ACID.

Oxygenated muriatic acid, in a liquid form, is of a greenish-yellow colour. It has a styptic bitter taste, and a very suffocating odour. Instead of reddening blue vegetable colours, it has the remarkable property of rendering them white. In high temperatures, when light is excluded, phosphorus remains unaltered

SULPHUREOUS ACID.

PART LXXIX.

THIS constitutes the imperfect degree of oxygenation of sulphur; that is to say, the sulphur is not fully saturated with oxygen. Sulphureous acid naturally exists in the gaseous state.

PROPERTIES OF SULPHUREOUS ACID.

The acid properties of sulphureous acid are not considerable. It does not reddens blue vegetable colours, but on the contrary renders them white. It exerts little action on metallic substances, and has a feeble attraction for the alkalies and earths. It is exceedingly volatile, and assumes the state of gas, if moisture be excluded.

For a fuller account of this acid we refer our reader back to sulphureous acid gas, vol. I, p. 317.

METHODS OF OBTAINING SULPHUREOUS ACID.

1. To prepare sulphureous acid, take one part of mercury and four of concentrated sulphuric acid, put them into a retort, furnished with a receiver, and connected with Burkitt's or Pepys's

SULPHURIC ACID.

PART LXXVIII.

SULPHUR is capable of combining with two different proportions of oxygen; with the smaller quantity it forms sulphureous acid; with the larger, sulphuric acid. The last of these is the subject of our first enquiry.

PROPERTIES OF SULPHURIC ACID.

Sulphuric acid is in the form of a dense liquid, slightly viscid; it runs in *striae*, like oil, when poured from one vessel into another. Its specific gravity is in general 1.85, at least it is prepared of that strength in some of our principal manufactures.* In its pure state it is colourless and void of odour. It is of considerable fixity in the fire, and requires a strong heat for ebullition. On being mingled with water heat is instantaneously evolved. (vol. I. p. 51.) It is not altered by oxygen, nitrogen, or

* By Mr. Sandman in Queen Street, and Mr. Dobbs, Maid Lane, Borough.

PHOSPHORIC ACID.

PART LXXX.

WHEN phosphorus is united to oxygen the result is an acid, which varies according to the quantity of oxygen which joins to the phosphorus. Phosphorus uncombined with oxygen forms phosphoric acid.

PROPERTIES OF PHOSPHORIC ACID.

Phosphoric acid is capable of existing in a dry and crystallised state. When solid, and placed in contact with a small quantity of water, it dissolves, and affords a ponderous transparent fluid, void of odour. When exposed to heat it is rendered viscous; it gradually becomes more consistent, and loses its transparency. Lastly, when urged by a violent heat, in a silver or platina crucible, it melts into a transparent glass, which again attracts moisture when exposed to the air, and becomes converted into liquid phosphoric acid. When melted in an earthen crucible the acid acts upon it and fuses into a glass, which is *not soluble in water*, and exhibits no signs of acidity. It has a strong attraction for all the alkalies, and likewise for the earths. It acts only on a small number of metallic substances.

METHODS OF OBTAINING PHOSPHORIC ACID.

1. To obtain phosphoric acid the bones of adult animals are generally made use of. For that purpose, dilute in a spacious

glass jar, one pound of sulphuric acid with six or eight pounds of water; then add gradually, and with constant stirring, one pound and a half of finely pulverized bones burnt to whiteness. An effervescence will take place. When this has ceased leave the whole on a gentle sand-bath for a few hours, taking care to stir it frequently, and to supply the loss of water which happens by evaporation. After it has been suffered to remain undisturbed, strain the whole through a cloth, and wash the residual matter repeatedly in water till it passes tasteless. The fluid thus obtained contains the phosphoric acid, contaminated with lime, and may be evaporated in a Wedgwood's, or glass basin, to any wished-for consistence.

REMARK...The phosphoric acid obtained in this manner is not pure, but contains a considerable quantity of lime. To obtain it in its pure state, carbonate of ammonia must be added until no more precipitate falls down, the precipitate is carbonate of lime, which must be separated by filtration; the fluid being then evaporated to dryness leaves phosphate of ammonia. This is exposed to heat in a china cup, till all the ammonia is disengaged, which may be known by the mass frothing no longer, but flowing quietly. On cooling, it congeals into a transparent vitreous substance, called glacial acid of phosphorus, which attracts moisture, and is soluble in water.

2. Phosphoric acid may likewise be obtained by the rapid or complete oxygenation of phosphorus, by burning it in oxygen gas, as mentioned before, vol. I. p. 188.

3. *Scheele* has contrived a method of converting phosphorus into phosphoric acid without combustion; namely, by the action of nitric acid.

In this operation a tubulated glass retort must be half filled with pure nitric acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tubulure will be dissolved with a rapid effervescence, and a quantity of red vapour will be disengaged. The addition of phosphorus in small pieces must be continued until the last piece added remains un-

nitrogen, and the nitrogen becomes free and available.

The combination of phosphoric acid with organic acids called esterates.

MINERALS OF PHOSPHATE

There are two kinds, below the glow-pipe line. They are soluble in稀薄酸, from which they are derived. Most of them do not contain calcium with charcoal.

MINERALS OF CONTAINING PHOSPHATE

The minerals of these soils are the phosphates, calcium, magnesium, boron, and strontium. The phosphates are the combinations of these bodies. The phosphates are the most abundant minerals in the soil. The phosphate of strontium is principally found in the soil, and others of the phosphates are found in the soil.

PHOSPHOROUS ACID.

PART LXXXI.

WHEN phosphorus is burnt slowly, and does not become completely saturated with oxygen, it forms an acid differing from the former, called phosphorous acid.

PROPERTIES OF PHOSPHOROUS ACID.

Phosphorous acid is liquid, transparent, and of considerable density. It has an unpleasant taste, and emits an alliaceous and disagreeable odour when rubbed, and especially if warmed. When heated more strongly, part of it is volatilized in the form of a white vapour which is very acute, penetrating, and luminous in the dark. It is much more volatile than phosphoric acid; and always contains a greater or less quantity of phosphorus.

METHODS OF OBTAINING PHOSPHOROUS ACID.

To obtain phosphorous acid we merely expose phosphorus to the air: the phosphorus by this means undergoes a slow combustion, and is gradually changed into phosphorous acid. To

process, it is necessary to keep the phosphates in a closed vessel, and to prevent their exposure to the air of the laboratory. Care must be taken to prevent contact with other acids, as little as possible.

Phosphate acid with alkaline, terrestris, forms with volatile phosphates.

PROPERTIES OF PHOSPHATES

Phosphates decompose with oxygenated water, and in the open air they yield a phosphorus compound.

METHODS OF OBTAINING PHOSPHATES

Phosphate of potash, soda, ammonia, &c., are prepared by dissolving the respective carbonates in phosphoric acid, and proceeding as directed before, and strontium are produced by mixing phosphoric acid, and barytic or strontian water. Phosphate of lime is obtained by mixing phosphate of potash, &c., with lime.

CARBONIC ACID.

PART LXXXII.

CARBONIC acid exists, in the gaseous state, at common temperatures, and at any pressure of the atmosphere which we please. It is therefore a permanent, elastic, aeriform fluid, and has been considered as such under the article carbonic gas, vol. I. p. 234, to which we refer the reader for a fuller account of it.

The combination of carbonic acid with different bases, con-

stitutes CARBONATES.

PROPERTIES OF CARBONATES.

Carbonates produce a rapid effervescence when mixed with sulfuric, nitric, muriatic, &c. acids. Most of them are decomposed by heat. Some of them are insoluble in water, but become soluble by an excess of carbonic acid. Several of the fine carbonates change vegetable blues to green, and have an agreeable taste.

potash, or, by distilling potash with carbonic acid. Carbonate of soda may be prepared in a similar manner. Carbonate of magnesia is prepared by adding carbonate of magnesia to a solution of sulphate of magnesia as long as the latter remains in solution. Carbonate of ammonia is obtained by adding carbonate of lime with one of nitrate of ammonia. Carbonate of silver is precipitated by pouring a solution of nitrate of silver into a solution of carbonate of lime. Mercury is produced in a similar manner by mixing an alkaline carbonate with nitrate of mercury. Copper is precipitated by decomposing a solution of copper by adding to it a carbonated alkali. Nickel is precipitated by dropping into a solution of carbonate of soda or potash. Cobalt, nickel, or zinc, may be produced by decomposing the chlorides of these metals by the same alkalies.

NITRIC ACID.

PART LXXXIII.

PROPERTIES OF NITRIC ACID.

NITRIC acid is liquid, colourless, and transparent, possessing in a very eminent degree all the properties of acids. It tinges the skin yellow, which does not disappear till the *epidermis* wears off. It has a strong affinity for water, and has never yet been found in nature except in combination. It produces heat when added to water. When concentrated it exhales white acrid fumes on being exposed to the air, which are nitric acid in a gaseous state. When poured on oils, charcoal, &c. it sets them on fire. (See vol. I. p. 19.) It causes the sulphureous and phosphorous acids to pass to the state of sulphuric and phosphoric acids, by yielding to them part of its oxygen. It is capable of oxidizing all the metals except gold, platina, titanium, and tantalite.

METHODS OF OBTAINING NITRIC ACID.

Nitric acid cannot be produced in any considerable quantity, by the direct combination of its principles, without a great deal of labour; though that it may be so formed for the sake of experiment has been shown, vol. I. p. 211.

PART LXXXVI.

THE earliest chemists were interested in the detection of the nature of the poisonous white substance known now by the name of white arsenic. Subsequent experiments have shown that this substance is metallic arsenic at the first degree. The name of arsenic and its alloys is given in it. It is sometimes found in nature in sublimates, in volatiles, and in masses, or in stalactites among arsenic, cobalt, bismuth, and nickel.

PROPERTIES OF ARSENIOUS ACID.

Arsenious acid possesses a weak sub-acid taste, which it communicates to itself. Though of but a feeble acidity it nevertheless changes the texture of cabbage and limmus. If placed on quicksilver or on a red-hot iron, it is volatilized in the form of vapors, which has a strong smell of garlic. It is soluble in water. With phosphoric and boric acids it also... It decomposes the nitrates and the carbonates.

or cotton into the neck of the flask, and apply the heat of a lamp. A dense white smoke will be formed, and become precipitated on the internal sides of the flask. If the process be kept up till all the arsenic be oxidated, (which may be known by introducing a wire into the flask for a moment, which will become covered with a white crust, if the sublimation be not completed,) and the heat be then gradually augmented, the sublimed arsenious acid undergoes a sort of fusion, and an opake white mass similar to that met with in commerce is obtained.

2. The arsenious acid of the shops (or white arsenic) is chiefly obtained from arsenical ores of cobalt. These ores are thrown into a furnace resembling a baker's oven, with a long flue or chimney, either horizontal or winding, into which the fumes pass, and are condensed into a greyish or blackish powder. This is refined by a second sublimation in close vessels, with a little alcali to arrest the impurities. As the heat is considerable it melts the sublimed arsenious acid into those opake crystalline masses which are known in commerce, by the name of white arsenic.

Arsenious acid united with different bases forms salts called
ARSENITES.

PROPERTIES OF ARSENITES.

These combinations were formerly known by the fanciful appellation of *livers of arsenic*. They do not crystallize, but all of them appear in the form of a thick viscid yellow-coloured liquid, of a nauseous odour. They are decomposable by heat, and by the affusion of all the acids. They have been but very superficially examined, and are by no means sufficiently known to admit of a detailed description. They may be formed by dissolving arsenious acid in alcaline solutions.

TUNGSTIC ACID.

PART LXXXVII.

THIS acid does not exist in nature in an uncombined state, but always united to lime, (*tungstate of lime*,) or with iron and manganese, (*wolfram*.)

PROPERTIES OF TUNGSTIC ACID.

Tungstic acid appears in a pulverulent form, harsh to the touch. It is tasteless and insoluble in water. It is incapable of turning blue vegetable colours red, until it has been first rendered soluble by ammonia. It is of a yellow colour, which becomes blue on being exposed to the light, (vol. I. p. 125.) When put into muriatic acid with tin, zinc, or iron, it yields to them its oxygen, and hence the liquor becomes blue. It becomes also blue when boiled with sulphuric acid, and yellow with nitric or muriatic acid. Its specific gravity is about 6.12. It does not melt before the blow-pipe, but it becomes black when urged by the interior flame. With glacial acid of phosphorus it produces a transparent blue glass, if the inner part of the flame be directed on them, which loses its colour on being removed to the exterior part of the flame. It neutralizes alkalies, and is thus rendered soluble in water. Ammonia combined with it, or tungstate of ammonia, if dropped into lime-water, instantaneously throws down a precipitate which is tungstate of lime.

METHODS OF OBTAINING TUNGSTIC ACID.

Let one part of powdered tungstate of lime be digested in three of nitric acid, till it acquires a yellow colour. Decant

the acid, and let the remaining yellow powder, after being washed in distilled water, be digested in liquid ammonia till it is rendered considerably whiter. This ammoniacal solution is then poured off, and the residual undecomposed part of the tungstate is once more treated with nitric acid as before. The acid being again separated it is again digested with liquid ammonia, and so on alternately till it is totally decomposed.

The ammoniacal solution is then decomposed by the addition of nitric acid; the tungstic acid becomes precipitated in the form of a white powder, which, after being washed, dried, and exposed to heat, assumes a yellow colour.

RATIONALE... On adding nitric acid to the ammoniacal solution, nitrate of ammonia is formed, and the tungstic acid becomes separated, but this last is not perfectly free from ammonia, it is therefore necessary to heat it, or to wash it in diluted nitric acid, by which means the adhering ammonia is either volatilized or neutralized, which then may be washed away by means of distilled water.

The tungstic acid may also be obtained from the mineral called wolfram, in which it is combined with iron and manganese, and frequently with silex, in the state of a yellow oxid, as directed before, p. 16.

PROPERTIES OF TUNGSTATES.

These salts are very little known. Most of them, when dissolved in water, are decomposed by all the acids: these combinations occasion a precipitate, which is a triple compound, varying according to the acid employed.

METHODS OF OBTAINING TUNGSTATES.

Tungstate of potash, soda, or ammonia, may be formed by dissolving tungstic acid in the alkaline solutions. Tungstate of magnesia is obtained by boiling tungstic acid with carbonate of magnesia.

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METHODS OF OBTAINING MOLYBDIC ACID.

Scheele's method of obtaining molybdic acid consists in distilling about 25 or 30 ounces of diluted nitric acid from one ounce of native molybdena at five or more successive operations, that is to say, 4 or 6 ounces of the acid at a time. A great quantity of nitrous gas is obtained, and a white powder remains in the retort, which must be washed in distilled water to free it from the adhering foreign acid.

It may also be obtained by detonating molybdena in a red-heat with nitrate of potash. The residue left after detonation, when 4 parts of the salt to 1 of the metal have been employed, yields a colourless solution that contains the molybdate of potash, and which, upon a proper addition of water, lets fall the molybdic acid in the form of a white powder.

The union of molybdic acid with alkalies, earths, &c. forms salts termed **MOLYBDATES**.

PROPERTIES OF MOLYBDATES.

These salts are not better known than the last. A few with which we are acquainted, have the property of giving a green colour to phosphate of soda and ammonia when melted with it; and occasion a blue precipitate with muriate of tin.

METHODS OF OBTAINING MOLYBDATES.

The super-molybdate of potash, is the only salt that has been examined with tolerable accuracy. It may be produced by detonating one part of sulphuret of molybdena, with three of nitrate of potash, dissolving the mass in water, filtering the solution and evaporating it. Sulphate of potash first crystallizes, but if sulphuric acid be dropped into the remaining solution, super-molybdate of potash is precipitated.

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process of the recovery of the patients which requires that the proportion and methods of obtaining observations are well

COLUMBIC acid exists in the new furnace of iron.

PROPERTIES OF COLUMBIC ACID.

Columbic acid appears in the form of
crystals, whose colour does not become
nitric acid. It is soluble in sulphuric
acid in sulphuric acid, when mingle
white precipitate, which, when suffused
hence and then a grey colour. All the
possible by acids. *Columbic acid* has
flavour, nor does it appear to be solu-
moistened with this fluid, and placed in
it very soon reddens it. It expels the
oxygenated alkalies, and forms salts with
potassium, soluble in water, permanent
possible by nitric acid. Dissolved in water
when mingled with solutions of tungstic
ash, with carbonate of ammonia, and a
Columbic acid does not combine with an

ACIDS COMPOSED OF MORE THAN TWO BASES.

ACETOUS ACID.

PART XCI.

Acid exists combined with much mucilaginous and ex-
matter, and some portion of acidulous tartite of potash
common vinegar. When freed from them, it is called
acid, or distilled vinegar.

PROPERTIES OF ACETOUS ACID.

Acid is a perfectly colourless fluid, of an agreeable
odour, and pleasant sour taste, though frequently, (at
least not carefully prepared) it possesses more or less of
rheumatic flavour. It acts on almost all the metallic sub-

stances with a variety of im-
phenomena, and afford products of the greatest utility
arts, &c. Its affinity to earths, alkalies, and metallic
is inferior to that of the sulphuric, muriatic, and nitric

METHOD OF OBTAINING ACETOUS ACID.

Acetous acid is formed by the fermentation of wine, on which account it is called vinegar. However, wine is not indispensable necessary for its production as it is found in the urine of animals, &c. The vinegar produced during fermentation is far from being pure acetous acid, but may be obtained so by distillation. For this purpose choose the strongest vinegar possible, and having introduced it into a glass retort, place it in a sand-heat or rather in a water-bath. Adapt to the retort a large receiver and close the joinings. Then apply a gentle heat, and increase gradually, taking care to cool the receiver with cloths soaked in water. The first portion which passes over is an aqueous fluid, but the acetous acid soon ascends. This is what is called distilled vinegar.

The combinations of acetic acid with different bases form salts called ACETITES.

PROPERTIES OF ACETITES.

Acetites are decomposable by heat, the acetic acid is either disengaged unaltered, or decomposed. They are likewise decomposed by the affusion of sulphuric acid.

METHODS OF OBTAINING ACETITES.

Acetite of potash, soda, barytes, strontia, or lime, may be obtained by neutralizing the carbonates of these alkalies with acetic acid, evaporating the solution and crystallizing it. Acetite of lime or magnesia may be obtained in a direct manner. Acetite of silver is produced by dropping acetite of potash into a solution of nitrate of silver. Acetite of mercury is produced in a similar manner from nitrate of mercury, and acetite of potash. Acetite of iron, lead, zinc, and nickel, may be produced by dissolving these metals in acetous acid, evaporating the solution and suffering them to crystallize.

ACETIC ACID.

PART XCII.

THE acetous acid, deprived of part of its carbon, changes its nature; it acquires new properties, and then constitutes what is called acetic acid. The difference between the acetous and acetic acid does not depend, as was formerly supposed, on a different degree of oxygenation, but on the different proportions of carbon, which enter into its composition.

PROPERTIES OF ACETIC ACID.

Acetic acid has a more pungent sour smell than acetous acid. Its odour is so penetrating that when very concentrated it is impossible to support it for any length of time, it is even caustic and capable of corroding the skin. It is extremely volatile.

METHOD OF OBTAINING ACETIC ACID.

Take one part of acetate of potash, put it into a tubulated retort, lodged in a sand-heat, and pour gradually upon it half its weight of sulphuric acid. A violent action takes place, and part of the acetic acid becomes liberated in the form of white vapours. After the spontaneous action has ceased, distil with a gentle heat, and acetic acid will be obtained in considerable quantity.

OXALIC ACID.

PART XCIII.

PROPERTIES OF OXALIC ACID.

OXALIC acid is always concrete, its crystals are quadrilateral prisms, having their sides alternately broad and narrow, and terminating in two-sided summits. It is particularly distinguished by its strong attraction to lime, which is superior to that of any other acid. It is not altered on exposure to air. It acts upon most of the metals. Exposed to heat it becomes decomposed into carbonic acid, and carbonated hydrogen gas. It contains more oxygen than any other vegetable acid.

METHOD OF OBTAINING OXALIC ACID.

Oxalic acid is generally prepared by oxygenating sugar, in the following manner: Put one part of white sugar into a retort, and pour over it four parts of nitric acid, of about 1.567 spec. grav. adapt a receiver, and make the solution boil. When the fluid in the retort acquires a brown colour, add three parts of acid more, and continue the boiling till it again becomes brown, then add two parts more of acid, and continue the heat till the red fume almost disappears. Having done this,

suffer the mixture to crystallize. After having removed the obtained crystallized acid, the residue may again be treated in a similar manner as before, until no more crystals are obtained. It may then be purified by dissolving it in water, and re-crystallizing it repeatedly.

Oxalic acid united to alkalies, earths, &c. forms salts, called OXALATES.

PROPERTIES OF OXALATES.

The soluble salts formed by the union of oxalic acid with different bases, are decomposable by lime-water, the precipitate produced is soluble in acetic acid. Most of the alkaline oxalates are capable of combining with an excess of acid. The terrene oxalates are in general nearly insoluble, they are however all decomposable by a red heat.

METHODS OF OBTAINING OXALATES.

Oxalate of ammonia may be obtained by carefully saturating oxalic acid, dissolved in water, with carbonate of ammonia, and suffering the fluid to crystallize as soon as a pellicle appears. Oxalate of potash, or soda, may be obtained in a similar manner. Oxalate of lime is produced by letting oxalic acid fall into lime-water; the salt instantly becomes precipitated. Oxalate of strontia is formed by mingling a solution of oxalate of potash with nitrate of strontia; the oxalate of strontia precipitates instantly. Oxalate of barytes may be produced by dissolving barytes in oxalic acid to saturation.

TARTAREOUS ACID.

PART XCIV.

TARTAREOUS acid exists in the juices of many vegetables generally combined with lime.

PROPERTIES OF TARTAREOUS ACID.

Tartareous acid appears in the form of tabular crystals. Its taste is exceedingly sour. It is not altered by the air. It readily dissolves in water. It takes lime from the nitric, muriatic, phosphoric, and acetic acids. It has a strong tendency to unite to potash. In one proportion it forms a soluble salt, (tartrite of potash), but when the acid is in excess it forms a salt of difficult solubility, (acidulous tartrite of potash.) It is on this account that the presence of tartareous acid in any solution may easily be detected.

METHODS OF OBTAINING TARTAREOUS ACID.

To obtain tartareous acid, dissolve thirty-two parts of acidulous tartrite of potash in water, and throw chalk into it gradually till it is completely saturated, a precipitate will be formed which is *tartrite of lime*; decant the fluid, and put the tartrite of lime into a matress, pour over it nine parts of sulphuric acid and five of water; digest the whole for six hours, taking care to stir it from time to time; the tartareous acid will then remain free, and may be separated, by means of cold water, from the sulphate of lime which has been formed, and crystallized by suffering it to evaporate slowly.

REMARK...To ascertain whether the tartareous acid contains sulphuric acid, let fall into it a few drops of acetite of lead: if the precipitate, which is formed, be entirely soluble in acetone

acid, the fluid contains no sulphuric acid; if it is not soluble, sulphuric acid is present: to free it from this the fluid must again be digested over another quantity of the tartrite of lime.

The salts formed by means of tartareous acid, are called **TARTRITES**.

PROPERTIES OF TARTRITES.

All the tartrites are decomposable by a red heat; the basis is left behind in the state of a carbonate. They are decomposable by sulphuric acid. They are capable of combining with an excess of acid, forming salts, called super-tartrites. Most of them are also capable of combining with another base, in order to form triple salts.

METHODS OF OBTAINING TARTRITES.

Tartrite of potash, soda, or ammonia, is formed by dissolving the carbonates of these alkalies in tartareous acid, to saturation, and evaporating the solutions as directed so frequently before. Tartrite of strontia is precipitated by mingling a solution of nitrate of strontia with a solution of tartrite of potash. Tartrite of potash and lime is produced by dropping tartrite of potash into lime-water. Tartrite of potash and barytes, and tartrite of potash and strontia, are formed in a similar manner. Tartrite of potash and soda is produced by neutralizing a solution of acidulous tartrite of potash with carbonate of soda. Tartrite of potash and ammonia is obtained by mixing a solution of acidulous tartrite of potash with carbonate of magnesia. Tartrite of silver is produced by dropping a solution of nitrate of silver into a solution of acidulous tartrite of potash. Tartrite of mercury is precipitated by letting fall tartareous acid into a solution of nitrate of mercury. In a similar manner, tartrite of lead and tartrite of bismuth are formed. Tartrite of iron and tartrite of copper are produced by decomposing in a like manner, a solution of sulphate of copper, or sulphate of iron.

CITRIC ACID.

PART XCV.

CITRIC acid exists in the juice of lemons and oranges; in ripe grapes, cranberries, bilberries, and a variety of other sour fruits.

PROPERTIES OF CITRIC ACID.

Citric acid crystallizes in the form of rhomboidal prisms, which suffer no alteration from exposure to air. They are easily dissolved by water, and excite a very sour taste, which, when diluted, is exceedingly pleasant. One part of boiling water dissolves two of citric acid. It acts upon iron, zinc, tin, lead, and various other metals. Treated with nitric acid it becomes converted into oxalic and acetic acid. Exposed to a red heat, it becomes decomposed into carbonic acid, and carbonated hydrogen gas, and a little charcoal remains behind.

METHOD OF OBTAINING CITRIC ACID.

Saturate any quantity of boiling lemon juice, by adding to it gradually, pure chalk, in small quantities, until the effervescence ceases, on adding to it a new portion of chalk. During this process a white precipitate will be formed, and fall down to the bottom, consisting of citric acid and lime, (citrate of lime.) Separate this precipitate by transferring the whole on a strainer, and pour water over it till this fluid passes tasteless. Transfer the washed precipitate into a matress, or other convenient vessel, and pour over it as much sulphuric acid as will neutralize the chalk employed, having previously diluted the acid with six times its weight of water. Boil the whole about half a

hour, agitating it with a wooden spatula during the whole time, and then pour it on a filter, taking care to return the fluid, which passes through, back upon the filter until it becomes perfectly clear. Having done this, evaporate the fluid in a shallow vessel to the consistence of a thin syrup, and leave it to crystallize undisturbed. The crystals obtained are citric acid; in order to obtain them in a state of purity they must be re-dissolved, the solution must be filtered, and re-crystallized repeatedly.* Four parts of chalk require in general, for saturation, 94 parts of lemon juice. The citrate of lime produced amounts to about $7\frac{1}{2}$ parts. To decompose this, nearly 20 parts of sulphuric acid are necessary.

The combination of citric acid with different bases, forms the salts called *CITRATES*.

PROPERTIES OF CITRATES.

All the salts consisting of citric acid, when dissolved in water, are decomposable by the addition of tartareous and oxalic acid. They are likewise decomposed by sulphuric, nitric, and muriatic acids. A solution of barytes, mingled with a solution of citrate of potash, soda, or ammonia, produces an insoluble precipitate.

METHODS OF OBTAINING CITRATES.

Citrate of soda, ammonia, lime, potash, or magnesia, may be formed by dissolving the carbonates of these substances in citric acid, and evaporating the solution. The two latter do not crystallize. Citrate of barytes is precipitated by adding a solution of barytes to citric acid. Citrate of strontia is produced by dropping a solution of nitrate of strontia into citrate of ammonia. Citrate of iron and citrate of zinc may be formed by dissolving these metals in citric acid, and subsequent evaporation and crystallization. Citrates of silver, mercury, and lead, are obtained in a similar manner from the oxids of these metals.

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* Mr. Coxwell who has established a manufacture of citric acid, prepares it in a state of absolute purity; and at so cheap a rate as was formerly thought impossible to procure it.

MALIC ACID.

PART XCVI.

THIS acid is found in the juice of unripe apples, and in those of barberries, elder-berries, gooseberries, plumbs, and the common house-leek.

PROPERTIES OF MALIC ACID.

Malic acid cannot be obtained in a crystalline form, but appears always in the liquid state. Its taste is an unpleasant one. If left exposed to the air it gradually undergoes a spontaneous decomposition. Nitric acid converts it into oxalic acid.

METHODS OF OBTAINING MALIC ACID.

1. Take the juice of apples, saturate it with potash, and then add a solution of acetite of lead till it no longer occasions a precipitate; wash this precipitate, which is malate of lead; pour over it sulphuric acid till the liquor acquires an acid taste without any mixture of sweetness, and filter the whole, in order to separate the malic acid from the sulphate of lead which is formed.

2. Malic acid is also obtained by adding to the expressed juice of house-leek, a solution of acetite of lead, till no further precipitate ensues. The precipitate, after being washed, may be decomposed by sulphuric acid as before.

3. Malic acid may likewise be produced by distilling equal quantities of nitric acid and sugar, till the solution acquires a brown colour. The sugar is thus partly converted into oxalic and partly into malic acid. The oxalic acid may be separated by mingling the solution with lime-water, until no farther precipitate ensues; the malic acid is then left behind. In order to obtain it in a pure state neutralize it with lime, filter the solution, and mix it with alcohol. A coagulation now takes place, for the water separates, and the malic acid, united to the lime, may be obtained by filtration. Having done this let it be dissolved in water, and add to it a solution of acetite of lead until no farther precipitate ensues. This precipitate which is malate of lead, may be decomposed by sulphuric acid, as before directed.

Malic acid united to different bases, forms the salts called
MALATES.

PROPERTIES OF MALATES.

These salts are little known, they have been examined superficially by Scheele only. The malates of potash, soda, and ammonia are deliquescent. Malates of lime, barytes, and magnesia, are very insoluble.

METHODS OF OBTAINING MALATES.

Malate of potash, soda, ammonia, lime, or barytes, may be formed by dissolving these alkalies in malic acid, and evaporating the solutions.

the precipitate comes. The precipitate is a white, crystalline acid. It may be purified by repeated washings and crystallization.

Benzonic acid may also be obtained by evaporating benzene with a gentle heat, and covering the residue with a sheet of blotting paper. The acid remains and may be washed.

The salts which this acid forms are called benzene salts. Their properties are little known.

METHOD OF OBTAINING BENZOIC ACID

Benzoate of potash, soda, ammonia, barytes, etc., may be obtained by neutralizing benzoic acid with these alkalies. Separating the solution and suffering them to crystallize, the salts of alumine and magnesia are produced in a similar manner.

CAMPHORIC ACID.

PART C.

PROPERTIES OF CAMPHORIC ACID.

CAMPHORIC acid exists in the form of white crystals which effloresce in the air. Its taste is acid and somewhat bitter. It strongly reddens vegetable blues. It has little or no odour. It is very volatile; it is soluble in water, in alcohol, in sulphuric, nitric, and muriatic acid.

METHOD OF OBTAINING CAMPHORIC ACID.

Put into a retort one part of camphor and eight of nitric acid, distil the mixture, and repeat it three times on the same residue with a like quantity of acid; after the last distillation is accomplished, crystals will be found in the retort, which are camphoric acid.

The salts formed by camphoric acid with different bases, are denominated CAMPHORATES.

PROPERTIES OF CAMPHORATES.

All the camphorates known are easily decomposable by heat; urged with the blow-pipe they burn with a blue flame. Their taste is a saline bitter.

METHODS OF OBTAINING CAMPHORATES.

Camphorate of potash, soda, or ammonia, may be obtained by neutralizing these alkalies with camphoric acid, evaporating the solution and suffering it to crystallize. Camphorate of lime and alumine may be produced in a similar manner.

PRUSSIC ACID.

PART CIII.

THIS acid derives its name from the pigment called Prussian blue, of which it forms a component part.

PROPERTIES OF PRUSSIC ACID.

Prussic acid exists in the form of a colourless fluid. It has a strong odour greatly resembling that of peach-tree flowers, or of bruised bitter almonds. Its taste is sweetish but acrid. It is very volatile and inflammable when in the state of vapour or gas. It does not redden the most delicate vegetable blues. It is easily decomposable at high temperatures, and becomes converted into ammonia, carbonic acid, and carbonated hydrogen gas. It does not act upon any of the metals, but readily unites with most of their oxids. It has a great tendency to form triple compounds with alkalies and metallic oxids, and in that state it decomposes all metallic salts, and hence it is one of the most important reagents of the chemist.

METHOD OF OBTAINING PRUSSIC ACID.

The process is as follows: Put into a glass matrass two parts of pulverized Prussian blue, one part of red oxide of mercury

and six parts of water; boil this mixture for half an hour, agitating it frequently, then filter it, and pour over the residuum two parts more of boiling water, and having united the liquors, evaporate the whole to obtain crystals.

RATIONALE... The prussic acid quits the oxid of iron to unite to the oxid of mercury, with which it forms prussiate of mercury, which can neither be decomposed by acids nor alkalies. In order to disengage from it the prussic acid, dissolve it in water, or take the liquor above mentioned not concentrated: pour the quantity obtained in the preceding experiment, into a bottle containing about an ounce of iron filings, add nearly three ounces of concentrated sulphuric, or muriatic acid, and shake it well for some minutes: the mixture now becomes black, for the iron unites to the oxygen of the mercury, and combines with the acid. Leave the fluid at rest, and then decant it, and put it into a retort placed on a sand-bath; adapt to the retort a receiver, containing a little distilled water, to absorb the acid, and carefully lute all the joinings. By the help of a gentle heat the prussic acid, being more volatile than water, will pass over first; and when about a fourth of the liquor has passed, stop the operation.

The liquor which passes contains a little sulphuric acid: to free it from this acid, distil it again with a very gentle heat from pulverized chalk, and prussic acid will be obtained in the greatest purity.

Prussic acid may also be obtained by putting prussiate of potash and iron into a tubulated retort, and adding to it gradually sulphuric or muriatic acid, and heating the mixture; the prussic acid becomes disengaged, and is absorbed by the water previously put into the receiver.

The combination of prussic acid with different bases forms salts called **PRUSSIATES**.

a mere exposure to vivid light, or to a heat. All the metallic prussiates are insoluble, except mercury and manganese. These compound posable by acids. The triple prussiates are have been most particularly examined, on account of the important action they exercise upon other bodies.

METHODS OF OBTAINING PRU

Prussiate of potash and iron. The best methods for obtaining this important salt are the following:

Prepare pure potash, as directed before, pa-

Dissolve it in five times its weight of water, and add it to a glass receiver, placed in a sand-bath heated to 180° , and then gradually add the best Prussian blue, injecting new portions, as the former becomes dissolved, and supplying water as fast as it evaporates, until the solution is saturated. When the portions of Prussian blue are no longer dissolved, increase the heat to boiling, and continue it for half an hour. Filter the ley thus obtained, and saturate it with a solution of iron sulphate, moderately diluted; a precipitate will appear, which is the prussiate of iron.

therefore be subtracted from that of the precipitate in the test. Hence the weight of the crystals, in a given quantity of solution, should be noted, that the quantity of precipitation may be known. Care must be taken to heat till the oxid of iron becomes brown; for when it weighs considerably more than it should.

Prussiate of lime and iron may be obtained by dissolving 5 parts of Prussian blue, in about 56 of lime-water, for an hour, till the prussic acid is neutralized with the lime; it may be known by its not altering the colour of turmeric. *Prussiate of barytes and iron* is best prepared according to the method, by adding Prussian blue to hot barytic water; the portion added ceases to be discoloured; the solution is then filtered, evaporated, and crystallized. *Prussiate of iron* is produced in a similar manner. *Prussiate of Freiberg*, or *Prussiate of sian blue*, is prepared by igniting, with a moderate heat, 2 parts of dried blood and 2 of carbonate of potash. *Freiberg* is obtained, by the affusion of water. This is a green solution of one part of sulphate of iron of commerce and one part of alum; a green precipitate is formed, which, when dissolved in diluted muriatic acid, assumes a beautiful blue colour.

LACTIC ACID.

PART CIV.

THIS acid exists in the *whey* of milk.

PROPERTIES OF LACTIC ACID.

Lactic acid is capable of existing in the solid state; but it greatly attracts moisture, and becomes liquid. It has a sour taste. It strongly oxidates iron, zinc, copper, and various other metals.

METHOD OF OBTAINING LACTIC ACID.

Take any quantity of whey, evaporate it very slowly to one eighth, filter it, and then add to it lime-water till no farther turbidness appears. Filter the mixture again, and let fall into the fluid, diluted with water, a solution of oxalic acid, till it produces no further cloudiness. Then filter it and evaporate the fluid to the consistence of syrup, and mingle it with alcohol. Having done this separate the fluid again by filtration, add to it a small quantity of water, put it into a retort, and distil off the spirit; the remaining water then contains the lactic acid in a pure state.

The combination of lactic acid, with different bases forms salts called **LACTATES**. They have not as yet been examined with accuracy.

SEBACIC ACID.

PART CV.

PROPERTIES OF SEBACIC ACID.

SEBACIC acid exists in a concrete form. It crystallizes in needles. It is void of odour. Its taste is slightly acid. When heated it liquefies like tallow. It is soluble in cold water. Boiling water dissolves it very readily. It is also soluble in alcohol. It precipitates the acetites and nitrates of silver and mercury.

METHODS OF OBTAINING SEBACIC ACID.

Distil hog's lard, wash the product with hot water, and drop into it a solution of acetite of lead, till it occasions no further precipitate. Collect this precipitate, wash it, and dry it. Having done this, pour over it sulphuric acid and heat it; a substance resembling fat will then appear on the surface. This, being collected, dissolved in boiling water, and suffered to cool, crystallizes and is sebacic acid.

The combination of sebacic acid with different bases, forms the salts called SEBATES. Sebates of potash, soda, ammonia, or lime are crystallizable.

LACCIC ACID.

PART CVI.

THIS acid has been discovered by Dr. Pearson, in a wax-like substance called *white lac*, formed by certain insects of the coccus tribe. By exposing this substance to such a degree of heat as was just sufficient to liquify it, a fluid was obtained to which the Doctor has given the name of laccic acid.

PROPERTIES OF LACCIC ACID.

Laccic acid naturally exists in the fluid state. Its specific gravity Dr. Pearson found to be 1.025. at 60°. It strongly reddens paper stained with litmus. It has a saline bitter taste. When heated it smells precisely like newly-baked hot bread. On suffering it to be exposed to the atmosphere it becomes turbid.

BOMBIC ACID.

PART CVII.

THE phalæna, or moth of the silk-worm, particularly when in the state of a chrysalis, contains an acid liquor, said to be of peculiar nature. This acid is obtained by squeezing the juice from the chrysalis through a cloth, and precipitating the mucilage by admixture of alcohol. Or, it may be obtained by digesting the chrysalis in alcohol, mixing the infusion with a little water, and subtracting the alcohol by a gentle heat. The acid thus obtained is of an amber colour. It affords prussic acid when distilled with nitric acid. Its other properties and combinations are hitherto little known.

AMNIOTIC ACID.

PART CVIII.

VAUQUELIN and Buniva have discovered a peculiar acid in the liquor of the amnios of the cow, to which they have given the name of amniotic acid.

PROPERTIES OF AMNIOTIC ACID.

Amniotic acid exists in the form of a white pulverulent powder. It is slightly acid, but sensibly reddens vegetable blues. It is difficultly soluble in cold, but readily soluble in boiling water, and in alcohol. When exposed to a strong heat it exhales an odour of ammonia and of prussic acid. Assisted by heat it decomposes carbonate of potash, soda, or ammonia. It produces no change in the solutions of silver, lead, or mercury, in nitric acid. Exposed to heat, it yields ammonia and prussic acid.

Amniotic acid may be obtained by evaporating the liquor of the amnios of the cow to a fourth part, and suffering it to cool, crystals of amniotic acid will be obtained in considerable quantity.

Whether this acid exists in the liquor of the amnios of other animals is not yet known.

URIC ACID.

PART CIX.

THIS acid exists in the urinary calculi, and also in human urine. That species of calculus which resembles wood in its colour and appearance, consists almost entirely of uric acid. It was formerly called lithic acid, a name now superseded by the judicious remarks of Dr. Pearson, to whom we are indebted for a thorough knowledge of it.

PROPERTIES OF URIC ACID.

Uric acid crystallizes in thin plates. It has very little taste or odour. It is insoluble in cold, but soluble in 300 parts of boiling water, it then reddens delicate vegetable blus. It is not acted upon by muriatic acid. Sulphuric acid, assisted by heat, decomposes it. It is soluble in nitric acid, and communicates to it a pink colour. The solution tinges animal matter of the same colour. It combines readily with alkalies and earths, and forms salts, which are decomposable by most of the other acids. The combination of uric acid with potash or soda, forms compounds nearly void of taste. The last is found crystallized in the human body, forming the gouty concretions of those afflicted with the gout.

The acids called Formic and Zonic are nothing more than acetic acid.

CHEMISTRY OF VEGETATION.

GENERAL VIEW
OF
THE CHEMICAL PHENOMENA
OF
VEGETATION.

STRUCTURE OF PLANTS.

VEGETABLES are organized bodies, which are nourished by certain substances, received by and prepared within their vessels. They are all produced from seeds. They grow on the earth; at the bottom and on the surface of the ocean, and other waters; and *parasitical* upon other vegetables.

The structure of vegetables is nearly the same in all of them. They are composed of three principal parts, namely, the BARK, the WOOD, and the PITH. The bark is the outermost part: it covers the whole body of the plant or tree. On examining it minutely, it will be found to be also composed of three distinct substances, called the *epidermis*, the *parenchyma*, and the *cortical layers*. The *epidermis* is a very thin transparent membrane which covers the whole outer part of the bark. The *parenchyma* is placed below it: it is a succulent green membrane of a retiform texture. The *cortical layers* are the undermost: they consist of several thin membranes, composed of a multitude of lon-

itudinal fibres, which cross each other, and form a kind of network. The wood lies under the bark; it constitutes by far the greatest part of the tree or vegetable. It consists of concentric layers, which are composed of longitudinal fibres. The pith is situated in the centre of the wood: it is a very spongy substance, and contains a vast number of cells. Through all these different parts of the plant, vessels are abundantly distributed, by means of which the functions necessary for the life and re-production of the vegetable are carried on. The conditions necessary for that purpose constitute the chemical phenomena of vegetation.

PHENOMENA OF VEGETATION.

If a seed, which consists of three principal parts, namely, the *cotyledons*, the *radicle*, and the *plumula*, is placed in a situation favourable to its vegetation, it absorbs moisture, swells, and becomes soft. The *radicle* is converted into a root, and penetrates into the earth. The *cotyledons* emerge above the ground, and expand in the form of leaves, (called the *seminal leaves*); and the *plumula* becomes the stem, to which the leaves are affixed. The whole seed, during this time, changes to a substance of a saccharine nature, which serves for the first food of the plant. When these appearances take place the seed is said to *germinate* or *grow*. The food which was laid up in the seed for the embryo plant is then exhausted, and the plant derives its future nourishment principally from the air and soil.

FOOD OF PLANTS.

The food of plants consists of water impregnated with vegetable and animal matter, and several gases; but water and air form the principal part of the food of every vegetable. They are decomposed in the vessels of the plant. The hydrogen of the water is retained; the oxygen is also absorbed, but the greatest part of it appears to be evolved again by the leaves. Water also serves ^{to}

upply plants with carbonaceous matter, which it diffuses through the leaves, &c. and the same principle is absorbed from the air in the form of carbonic acid gas. These are the only sources whence the charcoal, contained in vegetables which grow in water and air, can be derived. The influence of heat and light are well known to be also very essential to the life of plants.

The manner in which the functions of vegetables are carried on is hidden from our view; they appear to be analogous to the organization and nourishment of animals, and therefore belong to the science of physiology.

IMMEDIATE PRINCIPLES OF VEGETABLES.

The immediate parts of vegetables which are obtained by simple, easy, and frequently mechanical extractions, and which constitute every kind of vegetable matter, are MUCILAGE, GUM; STARCH, or FECULA; JELLY; SUGAR; LUTEN; FIXED OIL; VOLATILE OIL; CAMPHOR; TAX; RESIN; EXTRACT; CAOUTCHOUC; ACIDS, ANIN; COLOURING MATTER; SUBER; and WOOD, LIGNEOUS FIBRE.

MUCILAGE, OR GUM. This substance is void of odour and taste. It is not fusible nor volatile. It is soluble in water, but not in alcohol or oils. It suffers no change on being exposed to air. Its solution in water is adhesive, and used as a paste. Nitric acid converts it into mucous acid, (page 318). It is found in all young plants, and often exudes spontaneously from certain trees; the species of *mimosa* are the most productive, particularly the *albida*. Gum arabic, and wild cherry-tree and plumb-tree gum exhibit samples of this kind. Cruikshank obtained from gum, exposed to heat in a close vessel, mucous acid, carbonic acid, dico-carbonate and ammonia; the residuum consisted of charcoal containing lime. Its principles are consequently oxygen, hydrogen, carbon, nitrogen, and lime.

STARCH, OR FECULA, constitutes the chief part of all the nutritive grains. Barley consists almost entirely of it. It appears in the form of a light, white, insipid, inodorous powder, soft to the touch. It is insoluble in cold, but easily soluble in boiling water, with which it forms a thick paste; which, when dried, assumes the appearance of a semi-transparent jelly, soluble again in hot water. Nitric acid converts it into oxalic and malic acid. It is inflammable. Starch may be extracted from wheat, rye, potatoes, &c. by beating or kneading the flour of the substances with a large quantity of water. This fluid takes up the finest part of the starch, and deposits it again; the water is then decanted, and the starch is suffered to remain in the water till it becomes sour; it is then washed repeatedly and dried. It is a ternary compound of carbon, hydrogen, and oxygen.

JELLY has a tremulous consistence. It is easily soluble in hot but difficultly so in cold water; when strongly boiled for some time it loses the property of gelatinizing.* It has a pleasant taste, and is always coloured by the fruit from which it is obtained. When dried, it becomes transparent like glue. It is obtained by pressing out the juice of ripe fruits, allowing it to repose, and boiling it up and straining it through flannel. The juice of blackberries, currants, gooseberries, &c. combined with sugar and gelatinized is well known.

SUGAR. Its properties are well known. It is very extensively diffused throughout vegetables; the juice of the sugar-cane, affords it in abundance: it is likewise obtained from the sugar maple; from the beet-root, &c. The process for the preparation of sugar is, to press the juice, to boil it with lime-water, and with the serum of blood; to neutralize some oxalic acid, and

* Hence the reason why in making jellies, if the quantity of sugar is not double that of the juice, it requires so long boiling to evaporate the superfluous water, and the jelly loses its gelatinizing property, or if it does gelatinize it soon spoils.

separate from it many impurities ; and then to evaporate it to a certain consistence, and cast it in a mould, or suffer it to crystallize. The constituent principles of sugar are, oxygen, carbon, and hydrogen.

GLUTEN is an elastic, ductile, seemingly fibrous, or membranous substance, insoluble in water, and putrefiable like animal matter. Its taste is insipid. It is slightly soluble in alcohol. It is dissolved by alkalies. Dried gently, it becomes semi-transparent, hard, and breaks with a noise and smooth fracture. It may be obtained by working or kneading flour repeatedly with water, the insoluble mass remaining is gluten. It may be obtained from the expressed juice of scurvy-grass, cresses, &c. by merely suffering it to stand exposed to the air, in order to separate the colouring matter, and then boiling it briskly for a few minutes. The gluten will coagulate, and may be separated by percolation. It consists of hydrogen, carbon, and nitrogen ; and differs from the preceding vegetable principles by containing a much larger portion of nitrogen.

FIXED OIL is an immediate principle in many vegetables. It is somewhat thick, mild, inodorous, or slightly odorous. It is inflammable when very hot, or reduced into vapours. It absorbs oxygen from the air, and thickens or becomes concrete. It is insoluble in water, and forms soaps with alkalies. Fixed oils exist rarely except in nutritive seeds or kernels, it is extracted by mechanical pressure, or by trituration in water. Oil of olives, linseed, &c. belong to this class.

VOLATILE OIL is a fluid of a strong aromatic odour, and acrid taste. It is very inflammable, and not easily saponifiable by alkalies. It is volatilized at 212° . It is soluble in alcohol. It dissolves resin and camphor, and is easily inflammable by the action of nitrous acid. It is usually obtained by subjecting vegetables to distillation with water ; part of it becomes dissolved by

that fluid, but the greatest part floats on the surface. Oil of lavender, rosemary, &c. are volatile oils obtained in that manner.

CAMPHOR is a white, concrete, crystalline, brittle matter, of a strong pungent taste and odour; highly volatile and inflammable. It is soluble in alcohol, ether, and oils; water takes up a minute quantity. It is soluble in sulphureous, muriatic, or fluoric acid gas. The nitric acid also dissolves it, but the camphor soon separates and floats upon its surface in the form of an oily-like fluid. It is principally extracted from the branches and wood of the *laurus camphora*, a species of laurel, growing in China, Japan, Sumatra, &c. by submitting them to distillation. The camphor thus obtained, is afterwards purified in this, and other countries, by re-subliming it. It exists in small quantities in thyme, rosemary, sage, and many other labiated plants; it may be extracted by distilling these plants, and exposing their oil to the air at a temperature between 22° and 54°. The oil gradually evaporates, and the camphor is left behind in a crystalline state. It consists of hydrogen and charcoal.

WAX. The obvious qualities of wax are well known. It is insoluble in water and in alcohol, but soluble in volatile and fixed oils. Alcalies form with it a soap. It is very fusible, and inflammable at a high temperature. Wax is formed on the anthers of flowers, whence it is collected by the bee. It is likewise found upon the upper surface of the leaves and fruits of many trees.

RESIN is either in the concrete or fluid state, it is soluble in alcohol, ether, or oils, but not in water. It melts at a heat not exceeding that of boiling water. Heated strongly it burns. It possesses a certain degree of transparency. Its colour is in general between yellow and brown. Resin frequently exudes spontaneously from plants, or flows out when they are wounded for that purpose. Sandarach, mastich, turpentine, &c. are resins.

EXTRACT exists abundantly in the juice of all plants; it is soluble in water, in alcohol, and in diluted acids; but insoluble in ether. It has a strong affinity for alumine. Exposed to air it gradually absorbs oxygen, and then loses its solubility in water. The same effect is produced by oxygenated muriatic acid. It is obtained by mechanical pressure; by the simple infusion of the plant in a liquid; or by its decoction in water, and subsequent evaporation. Its component principles are carbon, hydrogen, nitrogen and oxygen. Opium, liquorice juice, &c. are extracts.

CAOUTCHOUC, OR ELASTIC GUM, is a concrescible juice, remarkable for the great elasticity which it acquires when dry. It can be stretched to a considerable extent without breaking, and immediately contracts again when the force is withdrawn. It is soluble in ether and volatile oils. When exposed to heat it melts and burns with a bright flame. It is principally obtained by puncturing certain trees of South America, namely, the *haevea caoutchouc*, and the *jatropha elastica*. It is first thick and milky, and becomes concrete on being exposed to the air. The blackish colour of the Indian rubber of commerce is owing to the method of drying it. It exists also in the mistletoe, in gum mastic, and in various plants.

ACIDS. The acids which exist ready formed in vegetables are the citric, malic, oxalic, gallic, benzoic, tartareous, acetous, and suberic. They have been examined already under their respective heads.

TANIN is obtained in the form of a dry powder. Its taste is very astringent. It is soluble in water and in alcohol: the solution, when concentrated, feels unctuous to the touch, and froths, when agitated, like a solution of soap. Its principal property is that of forming an insoluble compound with animal jelly. On this property is founded the art of tanning. Tanin may be ob-

SPONTANEOUS CHANGES OF VEGETABLE MATTERS.

Having considered those immediate principles of vegetables, which constitute the body of the plant and which are discoverable by simple processes; we shall now examine the spontaneous changes they undergo from the re-action of their parts upon each other under certain circumstances.

It is well known that all organized substances, when dead, suffer certain changes, if placed in a certain temperature, and in contact with air and water. Our present task however is to consider only such changes as should be examined by the chemical philosopher, on account of the light they throw upon many of the phenomena of nature and art; we shall therefore begin with the theory of fermentation, of which three kinds are distinguished, the vinous, acitous, and putrefactive, characterised principally from each other by the nature of their products.

1. VINOUS FERMENTATION.

Before we consider this species of fermentation we must premise, that by the term fermentation in general, is understood a spontaneous motion which is excited in vegetable or other organized substances, and which totally changes their properties. The conditions necessary for that purpose are, a certain degree of fluidity, a certain degree of heat, and access of air.

All vegetable substances, containing saccharine matter, are susceptible of the vinous fermentation. When any sweet vegetable juice or other saccharine matter is suffered to be exposed undisturbed to a temperature between 60° and 80° F. it first becomes turbid and viscid; an intestine motion and increase of bulk gradually takes place; air bubbles are discharged from its whole mass, bursting forth with a perceptible noise, and forming a kind of froth or yeast; the sweetness of the fluid disappears, and a pungent taste is acquired. After a certain time these phenomena

cease, the fluid deposits a copious sediment, and becomes again clear, bright, and transparent. It has then acquired a brisk taste, a vinous odour, and an intoxicating power.

WINE.

Wine is the product of fermentation, obtained, under similar circumstances, from the expressed juice of the grape. The grapes are put into a vessel, exposed to a temperature of about 50° F. bruised and much agitated; after which the fermentation is excited, and the appearances before mentioned take place. When the fermentation ceases the wine is drawn off from the lees into casks, where it undergoes a second, though insensible fermentation, which more intimately develops its principles; and it is this change which causes the difference between *old* and *new wine*. Wine is more spirituous and intoxicating as the quantity of saccharine matter contained in the juice of the grape is greater. By processes similar to this, raisin, gooseberry, and other wines; cyder, and perry, may be obtained.

BEER.

Porter is made in this country from barley in the following manner: barley is first reduced to malt, by being steeped in water; it is then drawn off, and the barley is spread upon a floor about 6 inches thick, where it begins to germinate. The germination is suffered to continue till the radicle is $\frac{2}{3}$ or $\frac{1}{2}$ of the length of the grain. As soon as this is accomplished, the grain is spread thinner, and turned over twice a day, for several days; it is then transferred to the kiln heated with *wood*, and dried highly, or till it acquires a brown colour, it is then called *brown malt*,* From this malt, porter is brewed in the following manner:

A quantity of malt, freed from its germ, is coarsely ground and put into a vessel, called the mash-tub. Hot water, under the degree of boiling, (of about 160° or 180° F.) is poured on it, and the

* Malt very gently dried by means of *coke* for making ale is called *pale malt*.

whole is stirred intimately together, either by machinery † or by the hand of man; by this means the soluble part of the malt is extracted. When this operation is over, the liquor, called the *extract*, is drawn off. Another infusion is then made by means of water of a higher temperature, which of course is weaker than the former, and these are either mixt or kept separate. Both have a sweet taste, they contain the saccharine, the extractive, and the gelatinous parts of the grain. The infusion thus obtained is called *wort*. It is then boiled with hops to give it a certain aromatic bitterness, and to render it less liable to be spoiled in keeping; and is cooled as expeditiously as possible in very large shallow vessels called *coolers*, in which it measures no more than from 1 to 2 inches. As soon as it is cold it is transferred into the *fermenting-tub*, a certain quantity of yeast is added, and the whole is suffered to ferment. When the fermentation has advanced to a due degree, and the yeast ceases to rise, the beer is divided into smaller casks, to facilitate the separation of the yeast; and, lastly, it is conveyed into barrels, and kept in cool places, with the precaution of supplying the loss it suffers by evaporation. Eight bushels of malt, and 10lb. of hops produce upon an average 100 gallons of London porter.

ALCOHOL, OR ARDENT SPIRIT.

If wine or beer be distilled, a colourless fluid passes over into the receiver of a strong heating taste, a penetrating odour, and an intoxicating property. This fluid is called ardent spirit. It is capable of being inflamed without a wick, and burns without smoke, and with a flame which is blue at the edges and white in the middle. It is very volatile, and consequently evaporates spontaneously at common temperatures. It is miscible with water and alcalies. It dissolves resins, sugar, essential oils,

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† The first mechanical contrivance of this kind was invented by Edward Biley, Esq. a scientific brewer, to whom I am indebted for this account of brewing porter.

camphor, &c. It is decomposed by most of the dense acids: the result is a very odorous, pungent, inflammable, and highly volatile fluid, called *ether*.

To prepare *sulphuric ether*, any quantity of sulphuric acid is gradually mingled with an equal weight of alcohol in a retort; heat is then applied by a sand-bath, the retort being connected with a receiver kept cool by water; a colourless fluid condenses in the receiver. When the distilled liquor amounts to about half the quantity of alcohol employed, or when the neck of the retort becomes obscured with white fumes, the distillation is to be stopped; a thick black fluid remains in the retort. The distilled liquor, which is the ether, impure from the admixture of water and sulphureous acid, is to be mixed with a small quantity of potash, and subjected to distillation by a very gentle heat. It is thus obtained nearly pure.

RATIONALE.—The theory of the formation of ether is far from being accurately ascertained. According to the explanation which, till lately, was generally received, in the formation of sulphuric ether, the alcohol is decomposed by part of its hydrogen attracting part of the oxygen of the sulphuric acid: the balance of attractions existing between the principles of the alcohol being thus broken, a large quantity of carbon is precipitated, and the remaining elements of the alcohol combine, and form the ether.

Nitric ether may be obtained in the following manner: Two parts of alcohol are poured into a strong glass-bottle, provided with a ground stopper, and placed in a frigorific mixture, or in snow mingled with ice broken small, and in this situation the alcohol is suffered to cool some degrees below the freezing point. One part and a half of nitrous acid are then successively infused, yet by drops only, and at sufficiently long intervals, for fear of the mixture being heated, which, as likewise every agitation, ought to be most cautiously avoided. When the mixture is completed, the glass is for some time left standing quiet in the cold, and well stopped. The ether is, after this, found swim-

ming on the surface, from which it is carefully taken off by means of a separatory funnel, and cautiously rectified upon a little potash or lime.

RATIONALE.—The theory of the formation of nitric ether is not less obscure than that of the production of sulphuric ether. It has been ascertained by the experiments of Bayen, that the acid is either decomposed, or combined in such a manner that it is not discoverable by an alcali; he found that the mixture of the acid and alcohol, after being digested for some time, required only the ninth part of the quantity of potash for its saturation, which the quantity of acid employed would have done. The alcohol is also partially decomposed, as oxalic and acetous acids are formed. No carbon, however, is precipitated in a sensible form. It may be said, perhaps, that in this process, part of the carbon, hydrogen, and oxygen of the alcohol enter into new combinations, forming the acetous and oxalic acids; and that the remaining quantities of these elements combine with part of the acid to form the nitric ether.

Acetic and phosphoric ether may be obtained by distilling equal parts of the most concentrated acids of these kinds with alcohol, and proceeding as directed before. No good method of obtaining *muriatic ether* is hitherto known, the methods directed do not furnish a fluid which possesses all the properties of ether.

2. ACETOUS FERMENTATION.

If wine or any other vinous fluid be exposed to a heat, from 75° to 85° F. and air be admitted, the properties of the fluid are altered remarkably, it loses its taste and odour, it becomes sour, and turns into vinegar. During this change the fluid is rendered turbid, its surface becomes covered with a mouldy pellicle, a quantity of fibrous matter separates, and forms a kind of skin, which sinks to the bottom, vulgarly called *mother of vinegar*.

MUSCLES are thin, semi-transparent, soft, and pliable bodies, which wrap up or form the external covering of the muscles, bones, viscera, and other parts of the body. Mr. Hatchett has proved that they are devoid of phosphate of lime and saline matters, and that they are principally composed of coagulated albumen.

LIGAMENTS are those strong fibrous and elastic substances which connect the bones with each other; they have been little examined; they yield a quantity of gelatine, by boiling, but by far the greatest part remains unaltered.

TENDONS, commonly called *skeles*, are strong pearl coloured bodies which connect the muscles with the bones. By long and strong ebullition they are dissolved into a nutritious gelatinous mass.

THE SKIN envelopes the whole surface of animals. It is composed of three parts, namely, the *epidermis*, or *cuticle*, the *mucous membrane*, and the *cutis*, or true skin. The epidermis is an elastic membrane; it is that part of the skin which is raised in blisters. It is principally composed of albumen, gelatine, and phosphate of lime. The mucous membrane which is situated immediately under the epidermis, is composed of a soft gelatinous substance which gives to the skin its peculiar colour. The true skin, or cutis, is a thick, firm, elastic membrane, composed of a number of fibres interwoven with each other. Both this and the former are composed of gelatine, fibrin, albumen, and phosphate of lime.

FAT, TALLOW, and MARROW, are of an oleaginous nature, greatly resembling vegetable expressed oil. They may be considered as highly oxygenated oil, containing sebatic acid, and phosphate of lime.

AILS of animals, Mr. Hatchett has shown, are chiefly composed of a membranous substance, resembling coagulated albumen.

DENS and HOOS of animals greatly resemble the former in their properties.

AIR, according to Bertholet, yielded carbonate of ammonia, coal, nitrogen, and sulphur.

ZATHERS yield nearly the same products as hair. Mr. Hatchett has proved that the quill is chiefly composed of coagulated albumen.

HELLS, or the crustaceous coverings of certain animals, such as shrimps, lobsters, crabs, cray-fish, &c. and also the shells of fish, greatly resemble bones in their composition, but the proportion of the carbonate of lime they contain far exceeds that of phosphate. Mother of pearl is composed, according to Hatchett, of carbonate of lime and membrane. Fish scales are composed of membrane and phosphate of lime.

BLOOD is concrescible by repose and cold, and coagulable by heat. It separates into two different parts by rest. The cause of spontaneous separation is unknown. The white part is called serum, the other coloured part is denominated the *crassamentum*, or clot. The serum consists of albumen, gelatine, carbonate, muriate, and phosphate of soda, phosphate of lime, and sulphur. The crassamentum contains albumen, soda and sulphate of iron. When blood, the moment it is drawn from an animal, is strongly agitated with a stick or other substance, a white, solid, elastic matter separates, called *fibrin*, or animal albumen. It contains more nitrogen than any of the former parts of the blood.

MILK separates spontaneously into three parts, namely, *curd*, and *whey*. The first is a butyaceous oil, the *whey* caseous albumen, and the third a saccharine lymph. It is a compound of water, oil, albumen, gelatine, sugar, muriate of soda, sulphur, phosphate of lime, and muriate of ammonia.

SALIVA, which is secreted by the glands in the mouth, consists of mucilage, albumen, muriate of soda, phosphate of soda, phosphate of lime, and phosphate of ammonia.

TEARS consist, according to Vauquelin, of water, muriate of soda, muriate of soda, phosphate of lime, and phosphate of ammonia.

MUCUS OF THE NOSE is analogous to the latter acid. It contains more coagulable mucilage. Its great viscosity is owing to the absorption of oxygen, on being longer exposed to the air than to water.

BILE is a fluid secreted by the liver from the venous blood. It is composed of water, resinous matter, albumen, soda, phosphate of soda, phosphate of lime, muriate of soda, sulphur, salt, iron, and sulphurated hydrogen.

BILIARY CALCULI, or GALL-STONES, are concrete bodies deposited in the gall-bladder, and biliary duct. They are insoluble, very fusible by heat, partly soluble in alkalies, acids, or oils. They contain a bitter resinous matter, benzoic acid, lime, soda, and ammoniacal salts. They vary remarkably in their external properties and chemical composition.

URINE of healthy persons always contains phosphoric acid, phosphate of lime, phosphate of magnesia, carbonic acid, carbonate of lime, uric acid, benzoic acid, gelatine, albumen, (or a substance in which the colour and odour of urine principally resides,) resin, muriate of soda, phosphate of soda, phosphate of ammonia, muriate of ammonia, and sulphur.

URINARY CALCULI are frequently composed of uric acid, united to ammonia; others consist of phosphoric acid, combined with ammonia and magnesia.

WAX OF THE BEE is composed, according to Vauquelin, of albumen, soda, phosphate of lime, a colouring matter, and a bitter oil.

TRACHEAL HUMOURS, OR MUCUS, which lubricates the trachea and the bronchia; the ocular humours, the humours of the alimentary canal, and other cavities of the body have not been examined with attention. Fourcroy has ascertained that the faeces are always acid, and strongly reddens vegetable blue.

SINOVIA, or the peculiar viscid semi-transparent fluid, found within the capsular ligaments of the different joints of animals, Marqueron and Hatchett found to be composed of fibrous matter, albumen, soda, muriate of soda, phosphate of lime, and water.

SEMINAL FLUID consists of water, mucilage, phosphate of lime, and soda. The semen of other animals has not been analyzed.

LIQUOR OF THE AMNIOS, which surrounds the foetus in the uterus in every part, contains, in women, water, muriate and carbonate of soda, phosphate of lime, and albumen. In the cow, an extractive animal matter, sulphate of soda, and a peculiar crystallizable acid, called *amniotic acid*.

CEREBRAL PULP has been examined by Fourcroy. The pulpy matter of which it chiefly consists, approaches most nearly in its properties to albumen, which is mixed with a saline fluid, consisting of phosphate of lime, soda, and ammonia.

PERSPIRABLE MATTER has not been accurately analyzed, seems to be principally water holding in solution a small quantity of lymph and carbonic acid.

HUMOUR OF THE PROSTATE has not been examined. It appears to be albuminous, and of the same nature as all the humours.

CHYLE, AND THE PANCREATIC AND GASTRIC JUICES have not yet been analyzed with accuracy.

INTESTINAL GAS is composed ordinarily of many gases; principally of carbonic acid, nitrogen, carbonated and sulphuric acid, and hydrogen. The first is the ordinary product of a good digestion; the last are the sign and result of a troubled, slow, or irregular digestion.

SPONTANEOUS DECOMPOSITION OF ANIMAL MATTER.

The spontaneous decomposition which animal matter undergoes is called *putrefaction*. The conditions necessary are, a certain degree of moisture, a certain temperature, and a free access of air. The phenomena which attend putrefaction are the following. The colour of the substance first becomes paler, and its texture soft; it acquires an intolerable fetid odour, and its organization is destroyed. The substance increases in bulk, air bubbles are engorged, and the whole becomes gradually converted into a greenish black matter of a pulpy consistence; and lastly a phosphorescent light is frequently observable. In this state it remains for some time, sending forth a horrible offensive odour. This odour gradually disappears, the soft substance acquires a greater and more consistence, and becomes at last converted into a friable powder, resembling a mixture of earths.

It is obvious, that during this process all the principles, which form the organized animal matter, act upon each other according to certain laws; the precise nature of which has not been hitherto accurately ascertained. The gases which are developed, and which fill the cavities and cellular texture, so as to inflate and puff up the body, are evidently ammonia, formed by the union of the nitrogen and hydrogen of the animal matter; and afterwards phosphorated hydrogen, sulphurated hydrogen, carbonated hydrogen, and carbonic acid. In some cases nitric acid is formed. The earthy-like residue, which remains after the process of putrefaction has taken place, consists of charcoal, with other earthy and saline matters. Thus it appears that the elements, which formed the organized animal body, unite together, during the process of putrefaction, two and two, and form a new set of binary compounds of a more simple nature, which enter again with other substances, under favourable circumstances into new combinations, and thus serve for the reproduction and support of new organic and inorganic matter.

FINIS.

DESCRIPTION
OF
THE PLATES.

PLATE I.*

A. Perspective view of an improved Gazometer. It consists of a cylindrical vessel, made of japanned copper, or iron, *A.* and a glass cylindrical vessel, *B.* The japanned vessel is furnished with two stop-cocks, one of which is fixed at the top, and the other at the bottom, on opposite sides of the vessel. From the upper cock, a tube, *cc.* runs down the outside of the vessel, *A.* and under its bottom, to the cock, *b.* At the centre of the vessel a tube branches upwards through the bottom of the vessel, *A.* and thus a communication is made with the stop-cocks and the glass vessel, *B.* which is suspended in the vessel, *A.* by means of weights and pulleys contained in the bent tube, *aa.* A graduated rod, affixed, by means of a cap, to the vessel, *B.* expresses, the coincidence of any of its divisions with the aperture, *x.* the capacity of the emerged part of the glass vessel, and therefore measures the quantity of gas contained in it. In using this apparatus, the vessel *A.* is filled with water, up to the aperture of

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* Facing the title-page of vol. i.



ed upon the lower crucible, the fuel of course must be introduced through the lower aperture; and thus those chemical processes may be performed, which do not admit of the direct calcination of the fire. But if a reverberatory furnace be required for distilling out of earthen ware, or coated glass retorts, or applying an intense heat to bodies, capable of supporting a red fire, a retort, crucible, &c. may then be introduced, and an intense heat obtained by feeding the furnace, through the opening in the upper crucible. The intensity of the fire may be regulated by means of the door in the ash-pit.

Fig. 2 represents a self-acting blow-pipe, invented by Mr. Clarke, mathematical instrument maker. *A.* is a hollow sphere containing highly rectified alcohol, resting upon its shoulder *g.* Into the sphere, *A.* a bent tube, *b.* is screwed for conveying alcohol in the gaseous state to the flame at *o.* The tube is continued within the sphere almost to the top. The globe may therefore be nearly filled. At the top of the tube there is a safety valve, *c.* to prevent those accidents, which might otherwise arise from the expansion of the fluid, in case the heat applied should be too great. The pressure of this valve may be regulated at pleasure, by the two milled nuts, *e. f.* carrying the steel arm, *h.* which presses on the valve, *c.* The lamp which heats the alcohol is marked, *K.* It is made to stand to different distances from the sphere, *A.* by sliding up or down between the two pillars, *l l.* The distance of the flame, *o.* from the jet of the tube, is regulated by the wick-holder of the lamp, being a little removed from the centre of the brass tube, *m.* which is made to screw, and therefore gives to the wick-holder an eccentric motion. The opening for filling the sphere with alcohol is marked *i.* It is closed by means of a milled brass button, and collar of leather. *n.* is a mahogany stand supporting the whole.



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button, *a*, on the wheels, *b f.* the screw, *c c.* is put in motion, and, by its effect on the female screw, *d*, adjusts the wick to any required height.

Fig. 2, pl. iii. is a detonating or eudiometer tube of glass. Its bore is about half an inch, and its height 18. It is graduated into cubic inches, and sub-divided into decimal parts. By means of the two conductors, *a a.* a quantity of gas, confined in the tube by water or mercury, may easily be inflamed by the electric spark. Hence this tube is extremely convenient for showing the production of water, nitrous acid, or to expose a confined quantity of gas to an intense heat.

Fig. 3, the same plate, is an improved pneumatic mercurial trough, or tub. It consists of a mahogany box, of greater or less size, standing in a tray made of the same wood. The principal parts of this apparatus are the shelf of the trough and the bottom. The reservoir, properly so called, is the interval between these two planes. The advantage of this apparatus consists in having a broad shelf, fixed on one of the sides of the trough, and a sliding shelf, with a hole in the centre, which communicates with a funnel-shaped opening on the side of the large shelf. Vessels placed on the sliding shelf, may be conveniently filled with gas, by directing the conveying tube of a gas-bottle, or the neck of a retort, into this excavation, and then sliding it on the large shelf of the apparatus; which, from being on one side of the trough, enables the operator to perform his experiments with a less quantity of mercury, and in an easier manner, than in the troughs of the usual construction.

The tray, *b.* is useful for collecting the mercury which may be spilt.

PLATE. IV.

Fig. 1 is a perspective view of a portable universal furnace. It is made of strong wrought iron plates, and lined with fire-



Acoustic Thermometer at the end of Fig. II.

Fig. 4.



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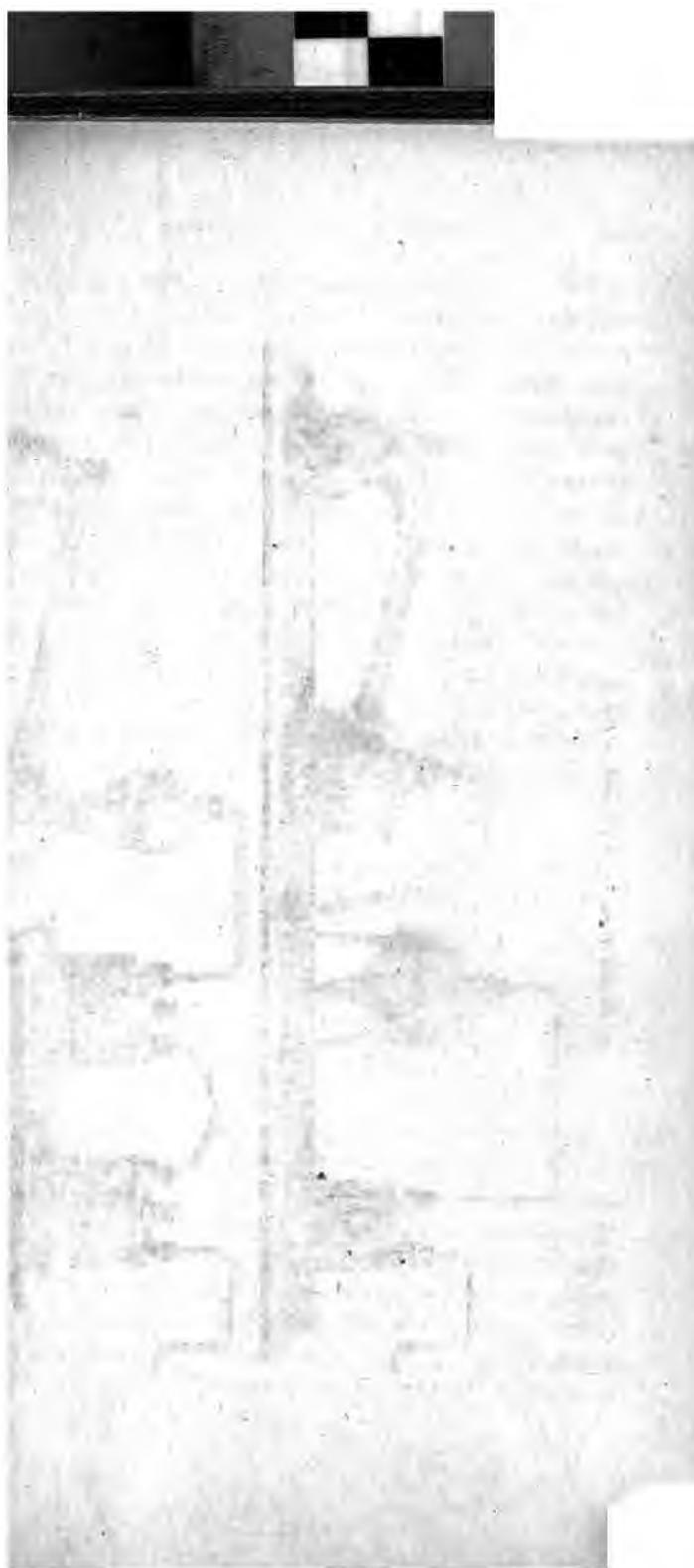


Fig. 4 is a flask for weighing gases. Its orifice is furnished with a brass cap and stop-cock. The flask is connected with a bell-glass in the manner stated before. If this flask has been previously exhausted by means of an exhausting syringe, and a communication be then made with the bell-glass by opening both cocks, the gas contained in the bell-glass may be transferred into the flask, by pressing down the bell-glass into the water of the pneumatic trough; the gas will then be forced up into the flask, the cocks being then shut, the flask may be removed, and its weight ascertained by means of a delicate balance. The difference between the weights of the flask when exhausted, and when filled, give the weight of the gas in the flask, which may, by the same method, be compared to that of common air, &c.

In a similar manner a bladder may be filled with gas by tying its mouth to a stop-cock, and screwing it on that of the bell-glass, by means of the connecting piece, and proceeding as just described.

Fig. 5 is a perspective view of a pneumatic cistern of which a description has been given already, page 178, vol. i.

PLATE. V.

Represents Burkitt's, and Pepys's distillatory apparatus for impregnating fluids with gases, &c.

Fig. 1....A. is a tubulated retort, joined to a tubulated receiver, *n*. From this a bent tube proceeds to the bottom of a second receiver, *g*, from the upper tubulation of which a communication is made, by means of a tube twice bent at right angles, with the two-necked bottle, *i*. The principal advantage of this apparatus consists in a valve, constructed by placing a plano-convex lens upon the mouth of the small tube, accurately fitted by grinding, and inserted into the lower aperture of the receiver, *g*. and similar to the valve in the well known apparatus of Nooth, but with more

water way. From this it becomes obvious that the gas disengaged from the retort, and not absorbed by the fluid contained in the receiver, *b.* will by its upward pressure raise the valve, and pass into the receiver, *g.* without allowing the fluid in that vessel to return into the receiver, *b.* even when a partial *vacuum* takes place in it. The gas which is not absorbed in the vessel, *g.* passes into the bottle, *i.* and if any part of the gas should escape absorption by the fluid in that vessel, it may be conducted into another bottle, or into the pneumatic trough, by means of the tube, *k.* In this manner, by a continued series of bottles, and tubes, the whole of the disengaged gas may be absorbed.

Fig. 2 is a similar apparatus, invented by Pepys, differing from the former, only by the vessel which contains the valve, being placed *upon* the first receiver: it therefore needs no description.

CORRECTIONS.

VOL. I.

Page 8, line 33, for *to* read *for*.

Page 99, line 14, for *Experiment I.* read *Experiment II.*

Experiment II. read *Experiment III.*

VOL. II.

Page 31, line 21, for *oxid of titanium*, read *oxid of uranium*.

Page 38, line 27, for *ore of borax* read *one of borax*.

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The Roman figures denote the volume, the Arabic show the page.

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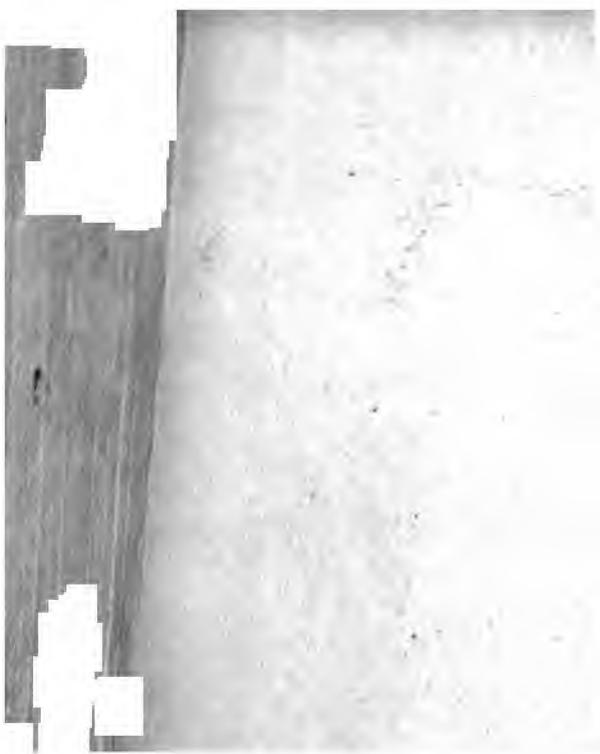
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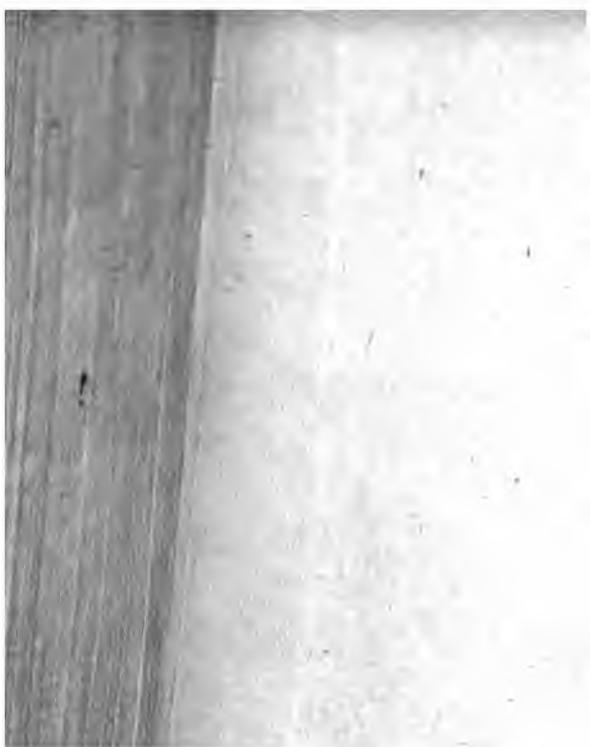
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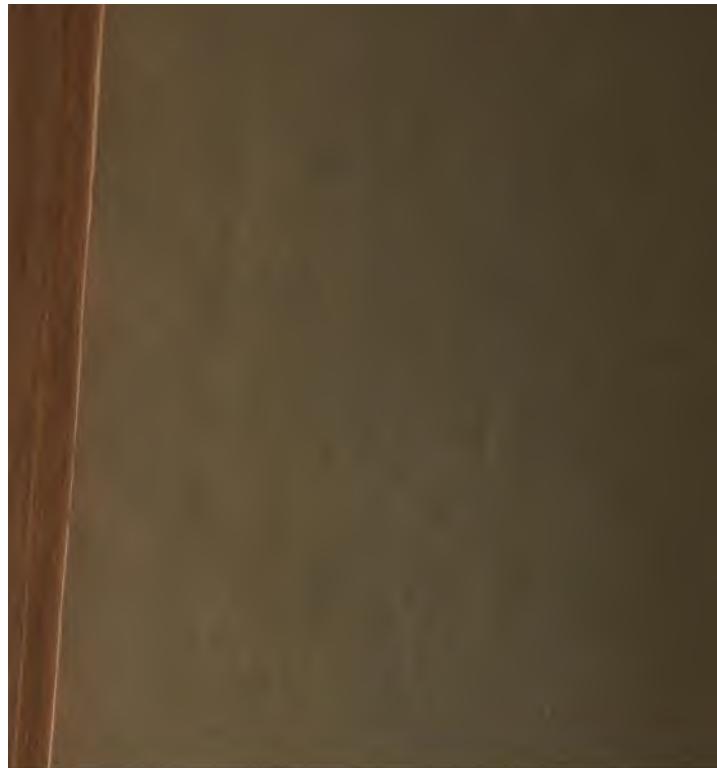
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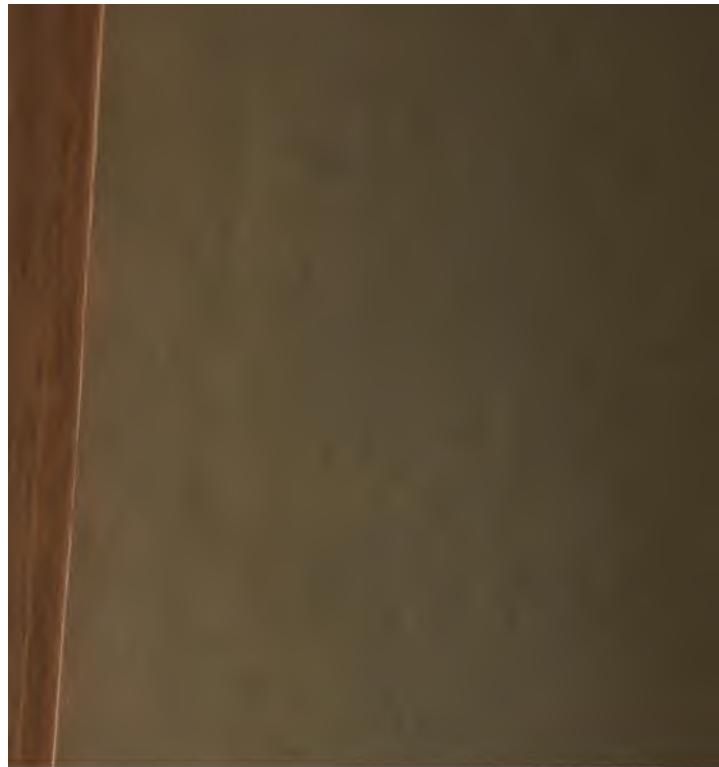
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